Compressed Air Magazine

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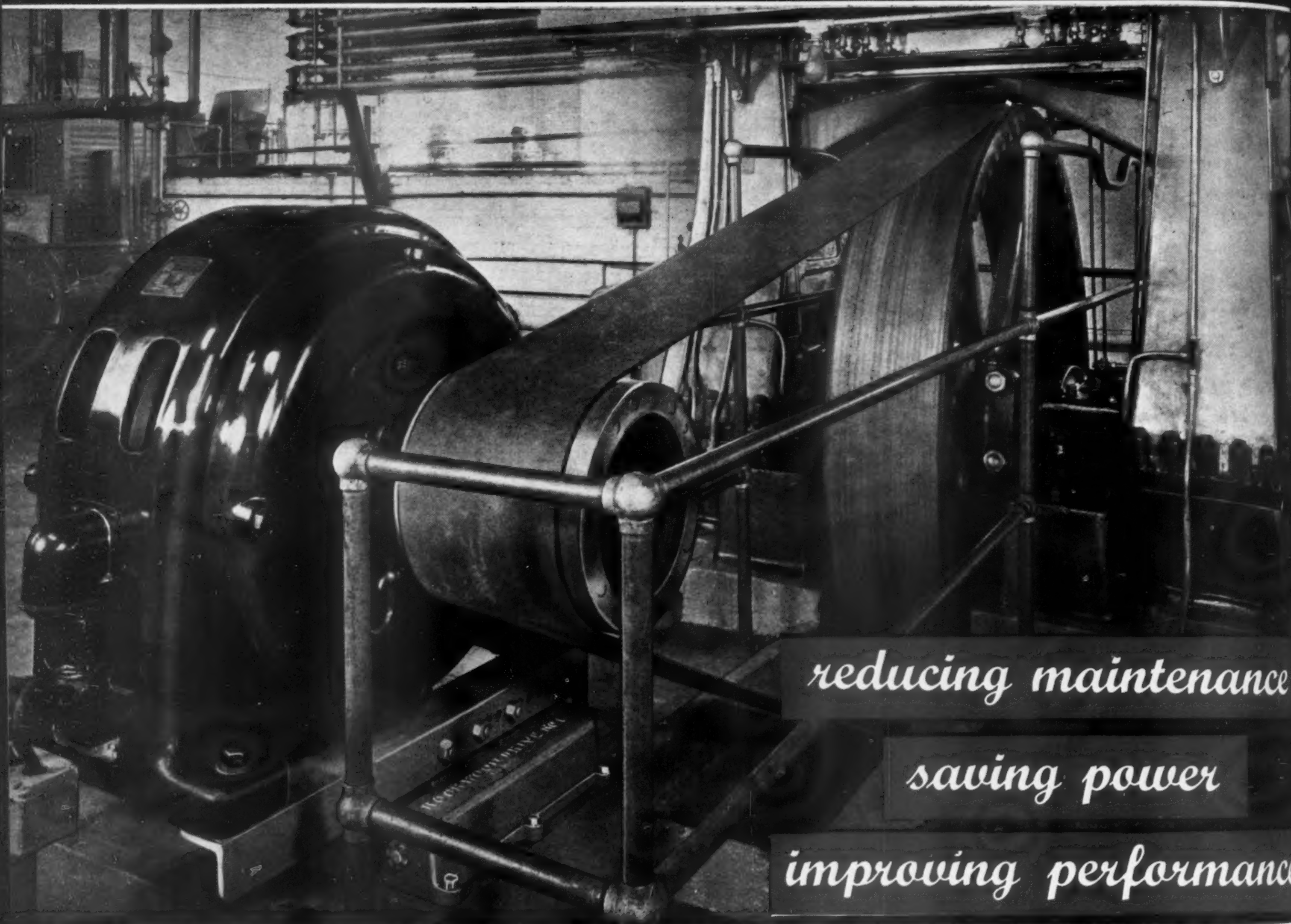
PLACING CONCRETE IN GRAND COULEE DAM

Typical Rockwood Drive Performance



Two Rockwood Drives save 4c per ton and help increase capacity from 60 to 80 tons per day

Typical of the experience you can expect from a Rockwood Drive on your compressor is this report by Charles Coneby & Associates, refrigeration specialists of Cleveland.

Installation is of two Rockwood Drives—one shown in each picture—at the Peoples Ice & Supply Co., Warren, Ohio. Each is a 100 h. p. synchronous motor driving a twin 11½ x 15 York ammonia compressor, operating at 164 r.p.m.

Mr. Coneby reports:—

"The change was made, the installation of both machines completed, both of them running through last summer season, and we feel justly proud of our engineering on this job and of the equipment used, because as a result of this change, we have increased the capacity of this plant from 60 tons per day to 80 tons per day. In addition to this, all ice produced shows a saving of 13.8 cents per ton.

"We are now convinced that at least four cents of this saving per ton, is due to the perfect installation of the Rockwood Base and flat belt drive. We have absolutely no transmission losses whatever. We are so proud of this installation, that we invite any one interested in perfect power transmission to visit this plant and witness its operation."

Act now! Write for A ROCKWOOD DRIVE recommendation for your old air compressor. Also SPECIFY ROCKWOOD DRIVES for YOUR NEW COMPRESSORS and save money on operation and installation from the start.

The Rockwood Manufacturing Company, **1800 English Avenue, Indianapolis, Indiana**

ROCKWOOD PIVOTED MOTOR DRIVES

Compressed Air Magazine

DECEMBER, 1936

Volume 41 Number 12

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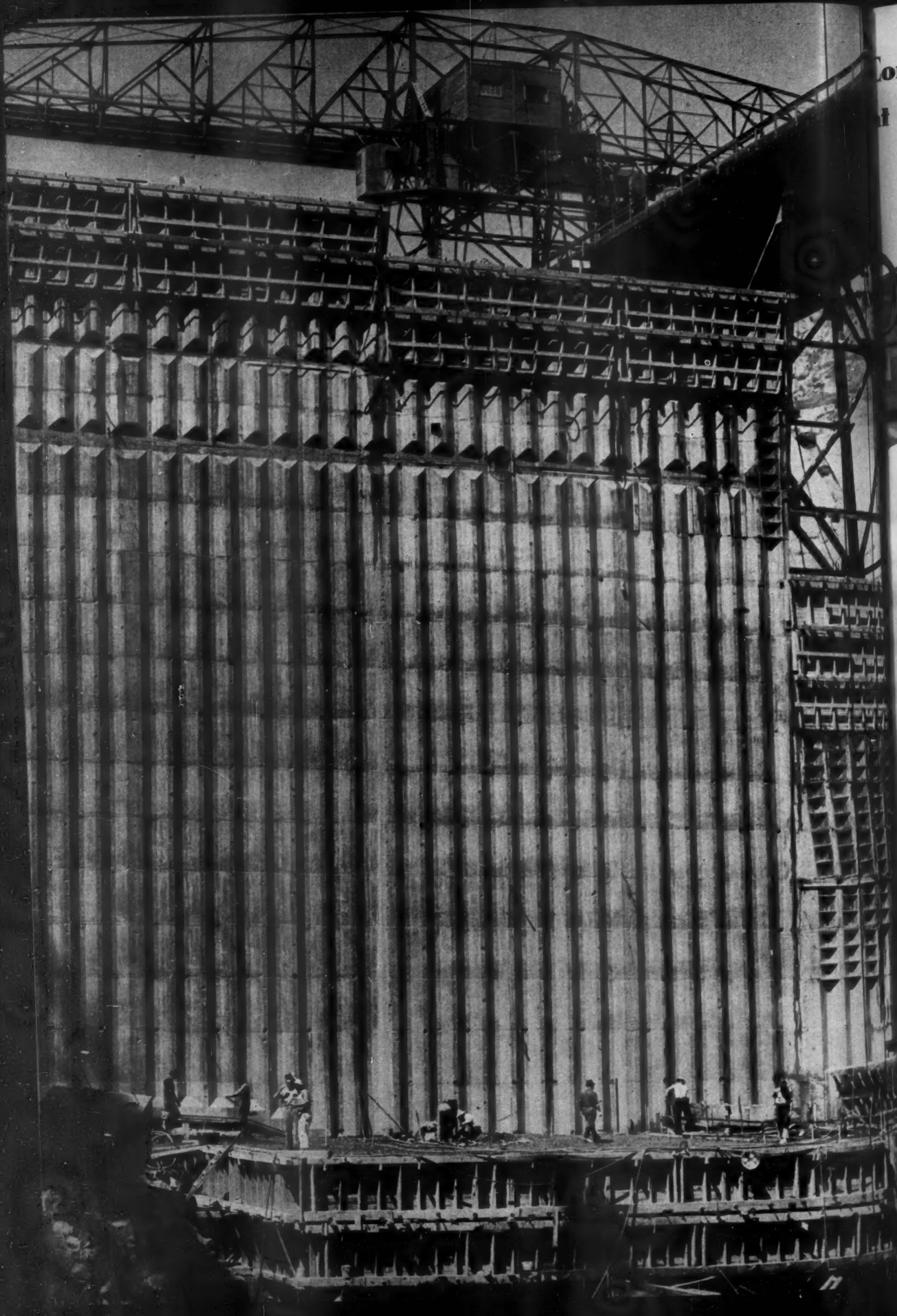
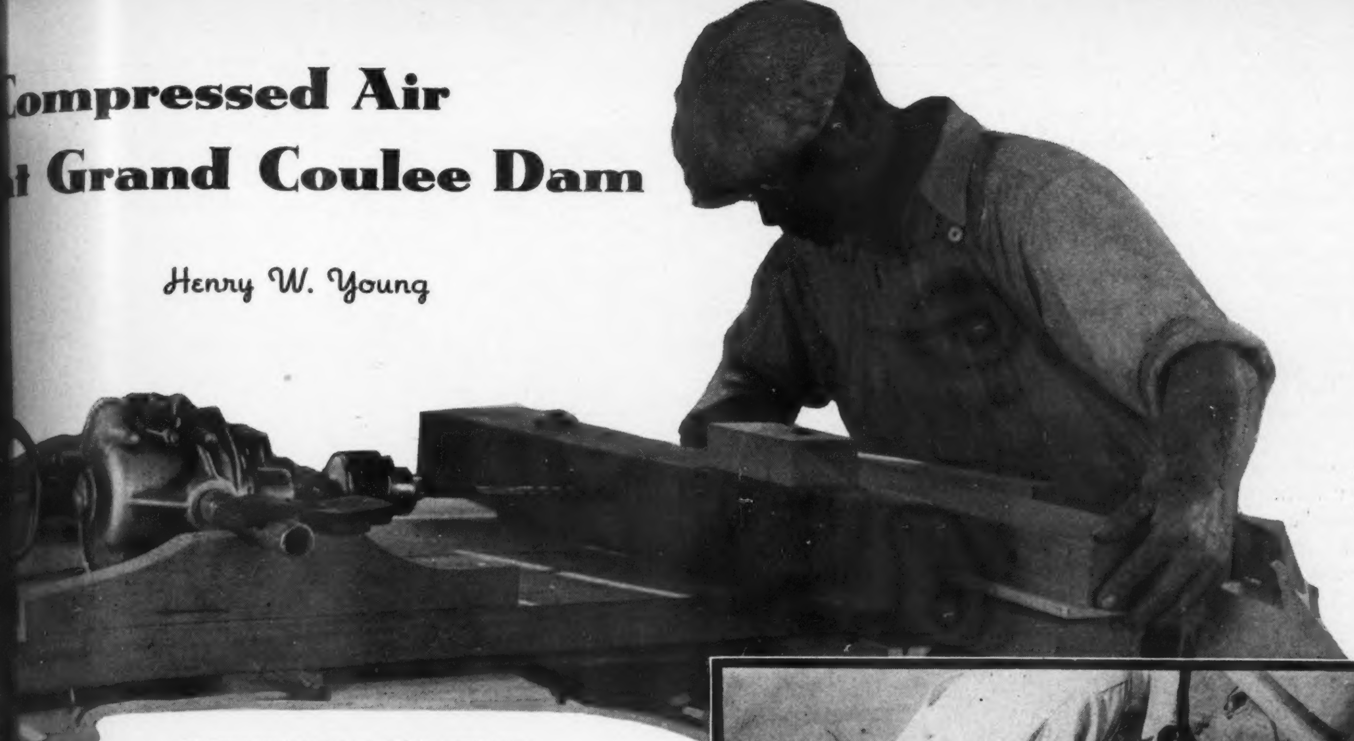


[C]ompressed Air [a]t Grand Coulee Dam

Henry W. Young



IMPROVISED DRILL PRESS

One of the carpenters working on concrete forms has mounted a CCW air-operated wood drill in a horizontal position on his bench (above). A sliding table enables him to push the work against the drill bit.

MAKING CONCRETE FORMS

An enormous amount of framing work has to be done in making up the forms in which the concrete is poured, and air-operated tools assist in many of these operations. Here a 4F sander is shown smoothing off the surface of a curved form. Two of these machines do all the work of this sort required. In the right-hand picture is a Size 28M angle wrench tightening the bolts on the panel of a form.

MUCH Columbia River water has flowed under the bridge at Grand Coulee since articles describing the construction work in progress there appeared in the September and October, 1935, issues of COMPRESSED AIR MAGAZINE. Those two accounts covered in considerable detail the object of the huge undertaking, the plans for carrying it out, and the methods employed by the dam builders during the first year of the operations. It is the principal purpose of the present chronicle to point out some of the numerous services that compressed air performs on a job of this magnitude.

Upon topping the jumble of hills overlooking the construction area, the first impression is that not a great deal has been done during the fourteen months that have elapsed since the last article was published. There is the same big dish-like depression scooped out of the two sides of the river. Inside it there is feverish activity; but the beginnings of the dam itself are just becoming evident. Only by closer inspection and by measuring with the eyes the progress that has been made on individual parts of the project does one come to a realization that much has actually been accomplished there. The enormity of the job is, of course, responsible for the initial deception.

In the west cofferdam area, all the excavating has been completed and the exposed foundation rock has been scoured as clean as a hound's tooth preparatory to depositing concrete upon it. Gone from the scene are most of the power shovels and the trucks and wagons for hauling muck. Gone also are the "Caterpillars" and the "Cat Skinners." The much publicized mile-long conveyor belt is still. The huge pile of earth and rock that it spewed into Rattlesnake Canyon is flattening out and weathering. Across the west cofferdam have now crept two steel trestles which are used for delivering the concrete. Two of the largest concrete-batching-and-mixing plants ever built have been erected, one on each side of the river. Receiving, mixing, and disgorging on a 165-second cycle, the four 4-cubic-yard mixers have been operating almost continuously for several months. They dump into buckets aboard cars that are speeded, in train loads, out upon one of the trestles to discharge into the forms below, where concrete is being poured in blocks 50 feet square. A million and a half cubic yards has already been deposited, yet its true bulk is not evident, for it lies in the thickest

A 100-FOOT CONCRETE CLIFF

[...]al face of one of the huge blocks of concrete, showing [...]ways for interlocking it with adjacent blocks. The [...]tal lines, spaced 5 feet apart, represent the tops of [...]al pours in the block. At least 72 hours are allowed [...]se before concrete is deposited for the succeeding [...] part of one of the cantilever cranes used in placing [...]te is seen at the top.

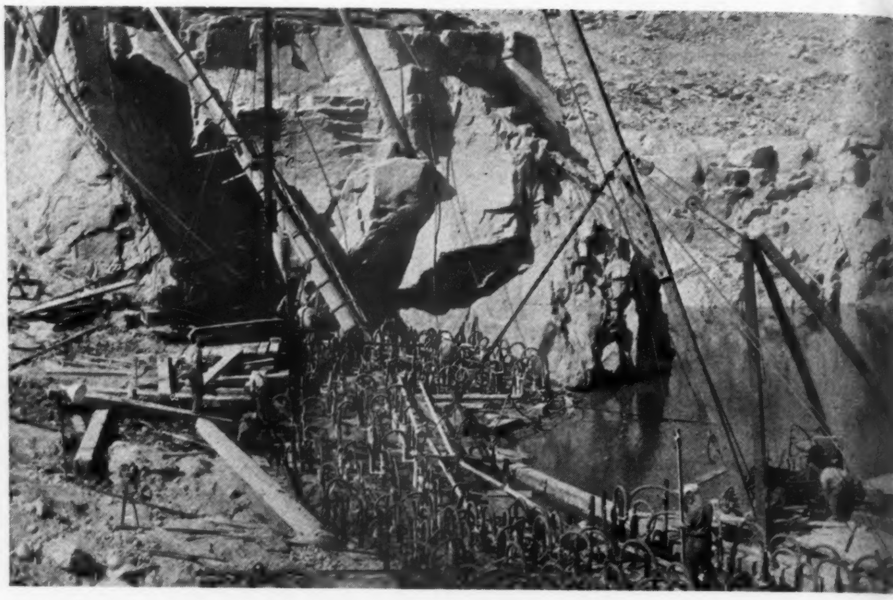
part of the dam and deep down on the canyon floor.

The steelwork of the concrete-placing trestle for the east cofferdam area is advancing from the east abutment toward the center, where it will eventually meet one of the trestles from the opposite side of the river. The Columbia is still flowing in the middle of its channel, but the cofferdam inclosing that portion is being built and the river will soon be diverted through the west-side area so that excavating can begin in the central section.

Down in the bottom of the east-side excavation the engineers are carrying out an unusual operation. It calls for the use of compressors, but they are compressing not air but ammonia gas. In digging there, the contractors encountered a fissure in the rock, and to be sure of obtaining a solid foundation it was necessary to excavate within this narrow cavity to a depth of some 100 feet. Fanning out above this crevasse was a great slope of clay that had been left in removing the overburden. Originally, the toe of this slope was nearly a quarter of a mile away from the fissure, but when high water inundated the east-side area in the spring of 1936 this great mass of clay, some 200,000 cubic yards, was loosened from its moorings and started to slide down the inclined rock surface toward the cleaned-out crevasse. Eventually it reached the edge of the opening and began to pour into it along a stretch 170 feet in extent. It was impossible to dig out the clay as fast as it entered, and a puzzling problem confronted the engineers. In the hope of arresting the progress of the slide they erected an arc-shaped retaining wall of concrete at the upper side of the crevasse. It failed in its purpose, for the river of clay merely filled up the space behind it, then flowed over the top.

It was then decided to freeze the toe of the slide by circulating refrigerated brine through it. Three-inch pipes were driven into the toe of the mass on 30-inch centers, an arc-shaped area being thus covered. The average depth of penetration was 43 feet, the aim being to carry the pipes down to a level below the top of the concrete retaining wall. One and one-half inch pipes were next inserted through nipples into the 3-inch pipes and extended nearly to the bottom of them.

The scheme was to introduce brine into the inner pipe; allow it to rise in the annular space between the two pipes; take it out near the top of the latter; return it to the cooling plant; and then recirculate it. In this manner it was planned to freeze the clay at the toe into an immobile mass, thus stopping further movement. The pipes were connected in series, in groups of sixteen. Valves were arranged so that brine might be admitted to or cut off from any group at will, or the rate of flow varied among groups to obtain the desired balance. Nearby, and at a location approximately 50 feet higher, was set up a refrigeration plant containing two 9x9-inch ammonia compressors having a combined capacity of 80 tons.



FREEZING A SLIDING HILL

High water last spring loosened a mass of clay which started sliding down the slope toward the east-side cofferdam area. A concrete wall, of which the top can be seen slanting across the picture at the right center, was constructed to block its path, but the clay overtopped it. It was then decided to attempt to freeze it, and for this purpose 3-inch pipes were driven to an average depth of 43 feet on 30-inch centers in the toe of the slide. A smaller pipe was inserted in each 3-inch pipe and refrigerated brine circulated through them. The nest of some 300 pipes and their hose connections are shown here. The method is proving successful; and on October 8 the temperature of the clay in this localized treatment area had been reduced to 8°F. With colder weather coming on, it is believed that zero temperature can be obtained. This picture was taken while some of the water that flooded the cofferdam last spring still remained in it. The operations are costing $30,000, but will save $100,000 according to the engineers' estimates.

Before the system was placed in operation it was necessary to make sure that there was no leakage at the connections between the 3- and the 1½-inch pipes. This was done by using compressed air at 100 pounds pressure. The pipes were capped and all tested at the same time. A gauge was fitted on each cap and the pressure observed for five minutes. Where a drop in pressure disclosed a leak, the pipe was pulled and repairs made.

Circulation of the brine was started in September. Soon the protruding ends of the pipes were covered with frost and ice. Viewed from above, they resembled a bed of mushrooms growing in a moist glade. Apparently the procedure has successfully served its purpose. The toe of the slide has been frozen solid, and the engineers are hopeful that it will hold back the viscous clay above it until the fissure can be filled with concrete.

There are two compressed-air plants at Grand Coulee, one on either side of the river. Each contains four large duplex, horizontal compressors, which are driven by direct-connected synchronous motors. Each plant has a capacity of 8,200 cfm. Combined, they can accordingly make available 16,400 cfm. of air, which is just 205 cfm. more than was provided at Boulder Dam. The receivers at each station are connected to a common 10-inch main from which 8-inch lines take off at four points and extend to various parts of the working areas. From these 8-inch lines, in turn, branch out numerous 2-inch lines. The resulting network covers both the east- and the west-side excavation. There are outlets at such frequent intervals that it is possible with the aid of hose connections to deliver air at 100 to 105 pounds pressure almost immediately at any desired place.

By following this manifold system of air lines, one inevitably comes upon many and diverse applications of compressed air. Its greatest use is, of course, for operating the rock drills that give dynamite its foothold in ripping away the vast quantities of rock that have to be removed. At this time, most of the drilling is being done in the east-side excavation and high up on the cliff on the west side where the foundation for the future pumping plant that is to supply water for irrigation is being blasted out. Hand-held drills of the "Jackhamer" type predominate. The general scheme of drilling is to put down 8-foot vertical holes on 30-inch centers. This makes it possible to use light charges of explosives.

Aside from drilling, compressed air also serves the concrete mixing plants—most of their controls, among other things, being air-operated. However, there are numerous other interesting and important applications of compressed air throughout the working areas, and it is with these that we are chiefly concerned here. Each one in its own way, be it great or small, saves time or money or both for the contractors.

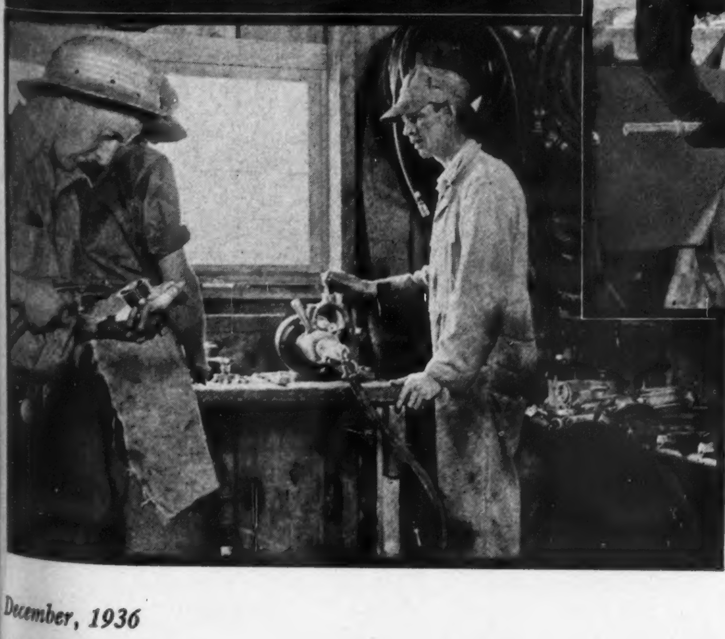
On the east bank of the river, near the freezing plant, work was recently started

DRILLING "TELL-TALE" HOLES

A size I-N pneumatic drill at work putting holes in the heads of staybolts in a boiler (left). Any weakness in a bolt is disclosed by steam escaping through the hole.

GRINDING CONVEYOR SCREW

Screw elements used in cement conveyors are subjected to much abrasion and are accordingly faced on their outer edges with stellite. After that the edges are ground down very carefully to obtain a close fit of the screw in the pipe in which it operates. A multi-vane grinder mounted on a lathe (below) performs this work at Grand Coulee.



RECONDITIONING DRILL STEEL

About 7,000 drill steels are reconditioned every 24 hours. Sharpening is done in two shops that collectively contain five air-operated sharpening machines. One of them, an I-R 54, is shown above. In addition to routine work, this unit forms and resharpens 5-inch bits that are needed for special grout-hole drilling. At the left is a corner of the shop in which pneumatic tools are repaired. On the bench is a 4K shank grinder used for truing up the ends of drill-steel shanks.

on the cribs for the upstream wing of the central cofferdam. These cribs, of foot-square timbers, are held together with drift bolts. They will be towed into position and sunk by loading them with rocks, after which they will be sheathed on the outward side with steel sheet piling. The jobs of boring the timbers and of driving drift bolts of slightly larger diameter through the holes would ordinarily require heavy manual labor with augers and sledges; but there those tasks are performed easily and quickly with CCW wood drills and CC-25 drift-bolt drivers, both air-operated.

At the west-side cofferdam, work is progressing on the world's largest timber crib. This is in Blocks 39 and 40. Without going into technical details, this huge structure is necessary to hold the water out of the central cofferdam area while it is being excavated and concreted. The river, meanwhile, will be diverted through the adjoining west-side cofferdam area. The crib will be 130 feet high, 200 feet long, and 100 feet wide. The timbers range from 12x24 inches at the bottom to 12x12 inches at the top. The amount of timber required will be 3,000,000 board feet.

Here the same type of wood drills and drift-bolt drivers are being employed, but in addition there has just been put to work another pneumatic tool. This is the Wolf chain saw, which is operated by two men and used for cutting off the ends of timbers. This tool is driven by an Ingersoll-Rand Type A air motor developing 3 hp. Not only will the saw develop more power per pound of weight than any other of its kind but it can also run underwater if necessary, and the occasion frequently arises.

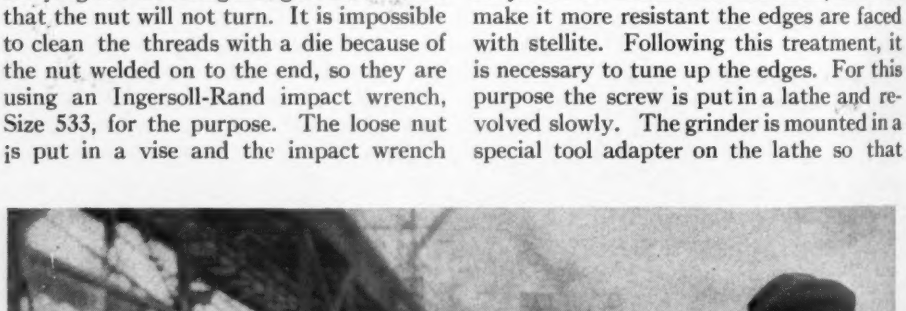
Not far from this scene concrete is being poured in the forms, and here the novice has his first introduction to "she" bolts. One end of these long bolts is hollow, with a thread inside for screwing on to the tie rod. This is accomplished by means of a nut which is screwed on to the thread on the outside of the opposite end of the bolt and which is then welded into place. However, in from the welded nut and traveling on the same thread is another nut for tightening up on the form when it is in position. This nut may be loosened again when the form is taken down.

Before these bolts get to the job they are thrown around a lot, and often the thread carrying the traveling nut gets battered so that the nut will not turn. It is impossible to clean the threads with a die because of the nut welded on to the end, so they are using an Ingersoll-Rand impact wrench, Size 533, for the purpose. The loose nut is put in a vise and the impact wrench applied to the welded nut, turning the bolt. Thus the threads of the bolt are run through the traveling nut, which acts as a die to clear them.

In the east-side yards and shops, where the forms are made, is to be found a number of pneumatic appliances. In one of the shops a carpenter has mounted a Size CCW drill horizontally on a bench and clamped it down. He has also rigged a sliding table at the end of the bench. For boring holes he puts the work in place on the table and pushes it against the bit.

There are almost numberless gallery-top and other curved surface forms to be constructed at Grand Coulee. Two 4F sanders are employed to dress down these surfaces. Care must be taken, for with No. 3 sand paper, if the operator gets to dreaming about what he is going to do with his Friday pay check, a flat spot is going to develop. So the disk is kept continually on the move, and by expert manipulation the two sanders are able to keep this surfacing work up with the rest of the operations.

In the machine shop not far away an I-R multi-vane grinder is being used to dress the augerlike screw element of a cement conveyor. One of these screws is about 6 inches in diameter. When turning within a pipe and thereby forcing the cement ahead it is subjected to continuous abrasion, and to make it more resistant the edges are faced with stellite. Following this treatment, it is necessary to tune up the edges. For this purpose the screw is put in a lathe and revolved slowly. The grinder is mounted in a special tool adapter on the lathe so that



BUILDING COFFERDAM CRIBS

Timber cribs of unprecedented size are being built for sinking in the river to form the center cofferdam. One of these cribs will require 3,000,000 board feet of timber. The bottom members are 12x24 inches in section. Air-driven tools perform numerous important services in making up these huge units. A 3-hp. Wolf saw (above) quickly eats its way through large timbers and can operate underwater if necessary. Holes for drift bolts are made with a CCW wood drill (upper left), and the bolts are driven with a CC-25 drift-bolt driver (lower left).

DETACHABLE BITS AID DRILLERS

In addition to vast quantities of solid drill steel, detachable "Jackbits" are extensively employed. For convenience in selecting the correct size, and to avoid loss, they are wired together in sets, as shown at the right. Above is a pile of used "Jackbits" awaiting re-sharpening.

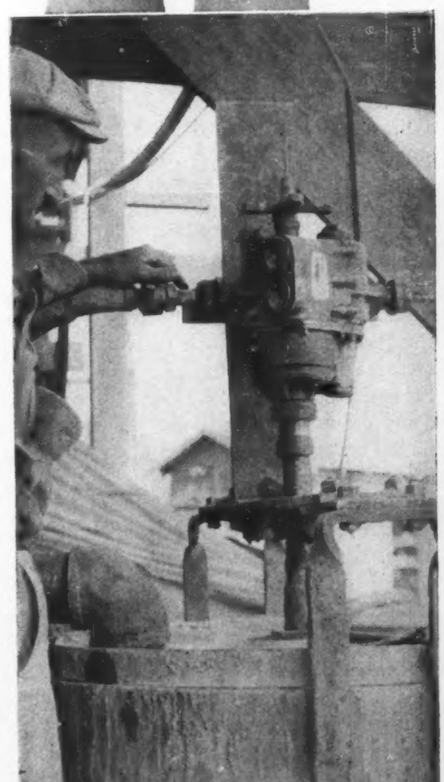
the grinding wheel, traveling at a high rate of speed, moves back and forth the length of the screw, taking infinitesimal thicknesses of metal off the high spots so that the fit of the screw will be exact. An Aloxite wheel, 6 inches in diameter and 1 inch thick, is used for this operation. Nearby a Size 1-N air drill serves to drill "tell-tale" holes in the staybolts of a boiler. Such holes, drilled to shallow depths on the inside head of the bolts, give warning in the form of escaping steam if failure of a bolt is imminent.

Above the west-side excavation stands the grout-mixing station. There is prepared the material for sealing crevices in the rock under the whole length of the dam. This is done in the conventional manner, by pumping cement grout under high pressure into holes drilled in some cases as deep as 200 feet below the foundation. Pressures from 200 up to 800 pounds per square inch are applied, forcing the grout into every minute fissure of the underlying rock. The holes are close enough together so that a continuous curtain impervious to water is thus formed deep under the dam.

There are four grouting units in the plant. In each is a mixer and an agitator. The purpose of the latter is to prevent separation of the grout before it enters the line to the high-pressure pump. Both mixer and agitator were designed and built by the contractors. An Ingersoll-Rand Type ASE pneumatic drill furnishes the motive power for each machine. It turns the paddle wheels of the 14-cubic-foot-capacity mixer as well as the vertical shaft, carrying a cone and blades, in the agitator. The agitator tank is about 3 feet in diameter and 3 feet high, and holds approximately 10 cubic feet of the mixture. The agitating mechanism operates at a speed of 84 rpm. That plants of this type will work successfully is proved by the fact that all four of them mixed approximately 135,000 sacks of grout from November, 1935, to September 1, 1936. In that time only one of the pneumatic-drill power units had to come down for attention. The largest run of the four plants in any 8-hour shift was 3,470 sacks.

Various holes are being drilled for grouting purposes. Of these one group that constitutes what are designated as "A" holes is of particular interest. It consists of a row of holes, spaced 5 feet apart, that will extend downward from the lowermost of the axial galleries through the dam. They will dip 80° toward the upstream side and will ultimately penetrate the underlying rock to depths of 75 and 100 feet. For the present, only the upper portions of these holes are being put down partly by drilling and partly by literally building them in the concrete.

Before any concrete is poured at these grouting locations, 5-inch holes are drilled in the foundation rock to a depth of from 3 to 5 feet, depending upon the contour of the rock surface. In these holes are inserted lengths of 3-inch pipe and, as concrete is placed, more lengths are added and the concrete poured around them. The ultimate length of each pipe is such that it will extend 3 inches above the floor of the 5x7-foot gallery. After the low-level dam is completed, diamond drills will be set up in the gallery and alternate holes, on 10-foot centers, will be drilled through the pipes and into the bedrock for 75 feet. These will be grouted under pressures up to 600 pounds. When the dam has reached its high-level elevation, the intervening holes —again on 10-foot centers—will be drilled



AGITATING GROUT

There are four grouting units in service, each including a mixer and an agitator. Air motors furnish the power for operating these machines. Above is shown a Type ASE drill mounted on top of a vertical shaft that extends down into an agitator holding 10 cubic feet of grout. The reliability of these air motors is demonstrated by the fact that up to September 1 the four units had handled 135,000 sacks of cement with only one of the drills having required repairs.

UNUSUAL USE OF AN IMPACT WRENCH

"She" bolts used for tightening the concrete forms receive rough treatment, and the threads on which the traveling nut runs are sometimes battered. They cannot be trued up with a die because access to them is blocked by a stationary nut welded on to the end of the bolt. To surmount this difficulty, the traveling nut is clamped in a vise and the bolt turned by an Ingersoll-Rand impact wrench that grips the fixed nut. The threads are quickly cleared by thus running them through the nut.

100 feet into the bedrock for further grouting.

Similar holes, spaced 10 feet apart and staggered with the "A" holes, are being provided for drainage purposes. The upper parts of these are being drilled simultaneously with the "A" holes in the granite foundation, and pipes are inserted in them and carried upward to the gallery level in the same way. In this instance, however, the pipes are of 4-inch instead of 3-inch diameter. Both groups of 5-inch holes are being drilled with X-71 blower-type drifter drills mounted on tripods. The bits are forged on 1½-inch hollow round drill steels, as will be described presently.

Several lines of holes, designated as "B" holes and used for low-pressure grouting, are drilled and grouted in the upstream section of the foundation area before concrete is poured. These holes are spaced approximately 20 feet apart and are staggered together with the holes in the neighboring lines. They are grouted under pressures ranging from 50 to 200 pounds, depending upon conditions.

The "B" holes are being put down with wagon-mounted drifter drills. They are started with 3⅝-inch bits forged on conventional steels and are drilled with these to a depth of 18 inches so that 3-inch grouting nipples can be set in them. They are continued to their ultimate depth with "Jackrods" and "Jackbits." The "Jackbits" range from 3-inch to 1⅞-inch gauge, the latter being the minimum size at which the holes can be bottomed under the specifications. The reduction in gauge with each change of bit is 1/16 inch. The initial group of bits was furnished by the manufacturer with 1/16-inch gauge variation between sizes. Afterward the contractors obtained the desired graduation by regrinding used bits and by purchasing new ones with ⅛-inch variation in gauge between sizes. Regrinding is done on Ingersoll-Rand "Jackbit" grinders, of which there are three on the job. "Jackrods" are forged on No. 54 sharpeners equipped with I-R thread forging dies. In the case of a hole of average depth, 30 feet, each size of bit has to drill approximately 18 inches in order that the hole, when finished, may not be larger than the specified minimum of 1⅞ inches. In practice, an individual bit usually drills from 6 to 18 inches before requiring replacement, and occasionally the footage obtained is such that the hole can be bottomed at a diameter larger than that specified.

For convenience, a series of bits of the graduated sizes needed for each hole is strung on a wire loop in the order of the drilling sequence. This helps the driller to pick out the desired size of bit, and not only saves much time but also eliminates the confusion and the loss that take place when bits are lying around loose.

Breakage of bits is rare, but it sometimes happens, with the result that a piece of the bit remains in the hole when the drill rod is withdrawn. For recovering the lost portion, an electromagnet is lowered into the hole on a wire and current is supplied by six or eight dry cells. Success with this device is reported.

Drilling rock for blasting has been a big and continuous job for many months, and is accompanied by a barrage of high explosives at the end of every 8-hour shift. Conventional drill steels, with solid-forged bits, are used for this work. Most of the rock is a dense, hard, light-colored granite of fine grain, and is hard on drill bits. Last fall, with 80 or 90 drills operating, steel was sharpened at the rate of 8,000 pieces every 24 hours, and the aggregate reduction in the length of steels amounted to from 1,200 to 1,500 feet per day. At present, from 1,500 to 2,000 steels are being reconditioned every 6-hour shift, the daily average being around 7,000.

Under such conditions, almost factory-size plants for drill sharpening must be maintained. There are two of these, one on each side of the river. In the west-side plant are two Ingersoll-Rand drill sharpeners: a No. 50 and a No. 54. In the east-side plant, one of the two machines installed is an I-R No. 54 that has so far been moved five times to keep close to the drilling operations it serves. The latter is used for sharpening the 5-inch drill steels with which some of the grouting holes are started. The dollies furnished as standard equipment did not run higher than 4⅞ inches in size, therefore a 5-inch dolly was made in the shop at the dam. Despite the fact that this exceeds the rated capacity of the machine, it worked as satisfactorily in forging 5-inch bits as it did when forging smaller ones. Jack Meehan, foreman of drill-sharpening operations, expressed the belief that even larger dollies could be made and used if that were necessary. As a point of interest, and to indicate what a sharpener has to do, it may be mentioned that it takes a 28-inch length of 1½-inch drill steel to make one 5-inch bit.

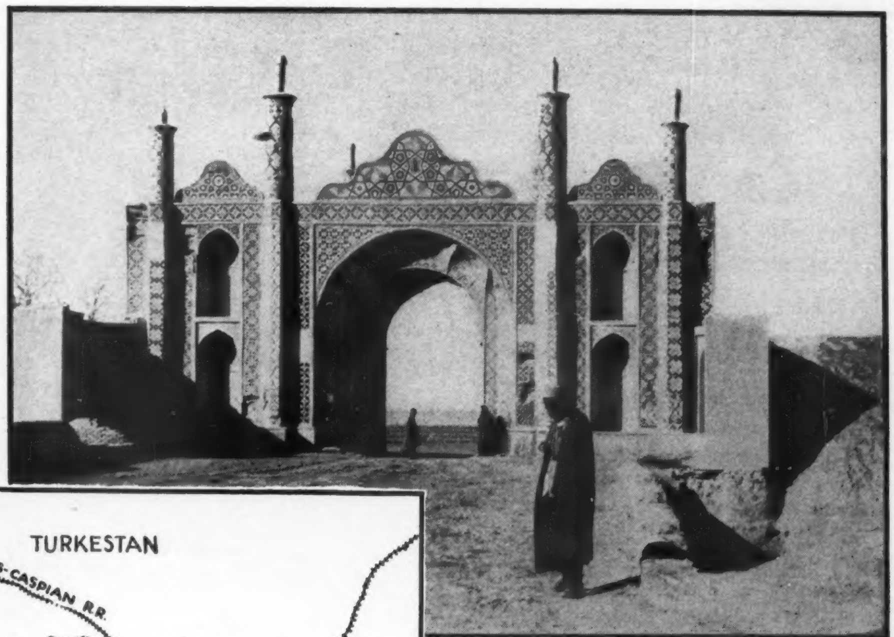
The foregoing presents, at best, but a few of the applications of compressed air on this vast project. Most of these are out on the job. There are many others in the shops, as well as in connection with the machinery and equipment used in the actual construction of the dam. Even the trucks are provided with air brakes. The electrically controlled, air-operated mechanisms of the concrete mixers, the means for actuating the gates and for loading the aggregate belts, the system for blowing cement a mile from the silos, all would make stories in themselves. But the aim of this article is to show that the smaller and less spectacular applications also have their places. If some have been left out it is because no single pair of eyes can penetrate all the nooks and corners of Grand Coulee's immensity.

Grand Coulee Dam is being built for the U. S. Bureau of Reclamation—of which F. A. Banks is construction engineer—by the Mason, Walsh, Atkinson, Kier Company. T. J. Walsh is president of this company; Guy P. Atkinson, vice president; George H. Atkinson, job manager; M. H. Slocum, general superintendent; and C. D. Riddle, chief engineer.

In the center of this issue there appear two pages of pictures that show the progress of the work and some of the methods of operation being employed.

Building a Railroad Through Iran

J. H. Shotton



THE MESHED GATE OF TEHERAN

Teheran, capital and largest city of Iran, is situated on a gravel slope that extends downward from the foot of the Elborz Mountains for a distance of approximately 10 miles. It is a walled city, roughly octagonal in shape, and has twelve gates, one of which is shown here.

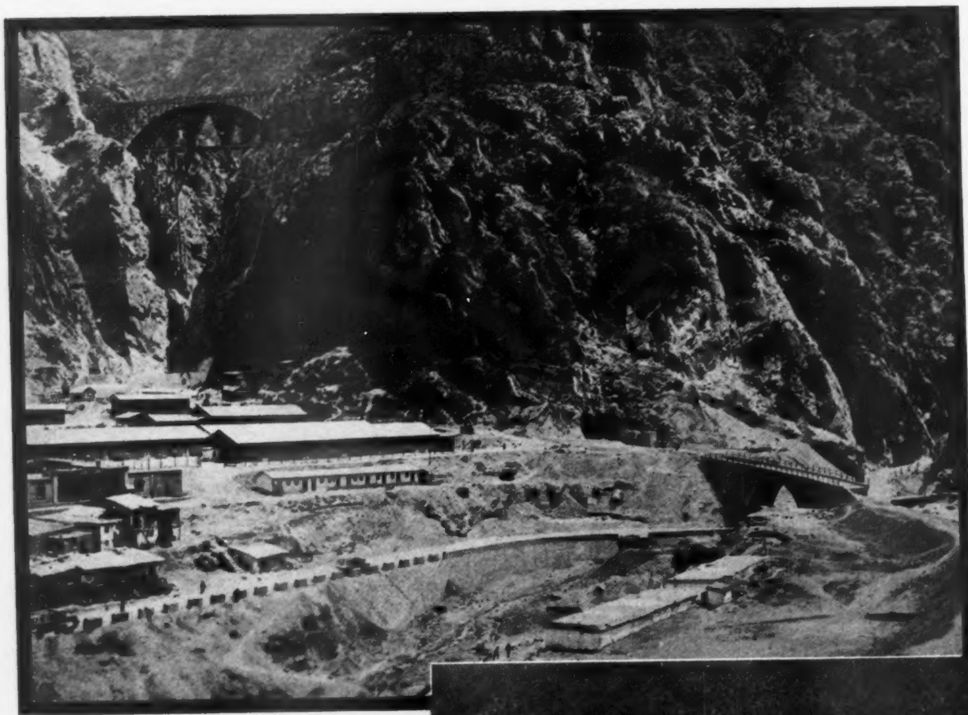
IRAN COMMUNICATION SYSTEM

Roads are indicated by light lines, railroads by cross-hatched lines of which the heaviest marks the through route now under construction. It will be 808 miles long, which is three times the length of all the previously existing railroads operated by the Iran Government as well as by India and private interests.

IN 1939, if the present building schedules are maintained, Persia, or Iran as the natives call it, will inaugurate service on a trunk-line railway which will have an important bearing on the economic development of the country. Work on the road was started in 1927, after Iran had won her political and financial independence under the rule of Shah Reza Pahlevi, thus enabling the government to undertake with its own resources an engineering project of vast proportions and one that had for years attracted the attention of some of the European powers.

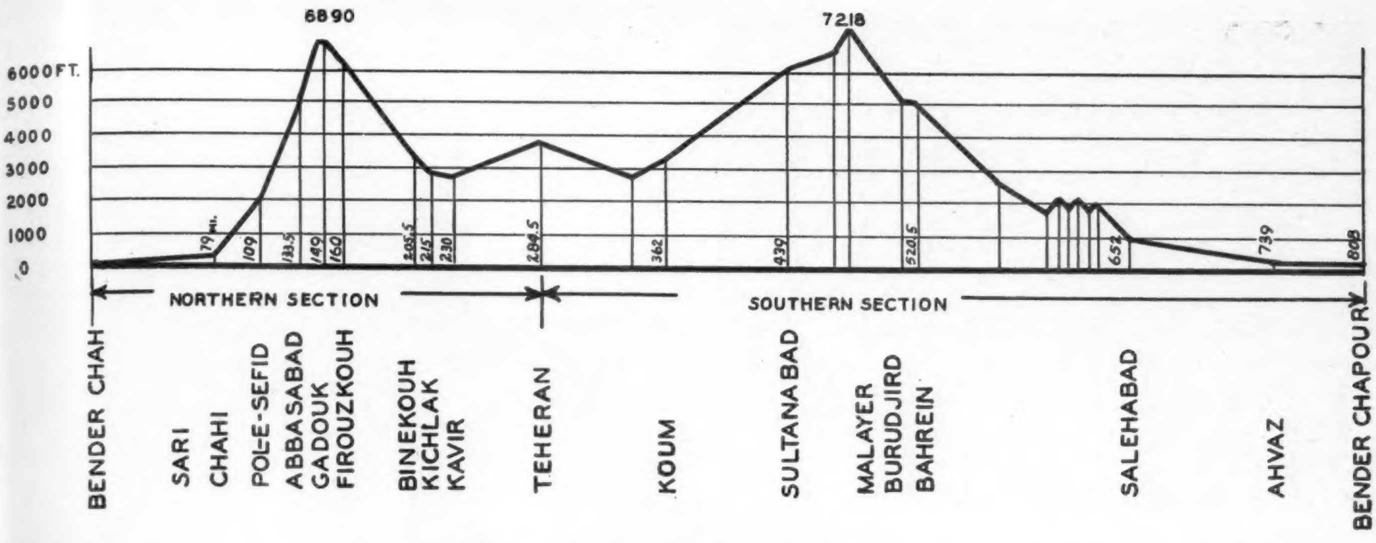
The idea of providing Iran with adequate means of communication goes back to 1911, when The Persian Railways Syndicate, a British concern, was formed for the purpose of constructing railroads in southern Persia. Without going into details, it is sufficient to say that the negotiations ultimately led to a plan for a more comprehensive system in which the lines lying within the Russian sphere of influence were to be built with Russian capital. The first of the roads contemplated by the syndicate was to extend from the Persian Gulf to the Caspian Sea—the general direction of the government railway now underway. Surveys were made according to these and to other plans that were proposed subsequently, but nothing came of them because of the intervention of the World War and of the conflicting interests of those concerned.

Prior to 1927, Persia, with a population estimated roughly at 12,000,000 and an area covering about 600,000 square miles, had but 266.5 miles of railroad of which none connected Teheran, the capital, with the rest of the empire and the outside world. There was but one short line running out of Teheran, and that was a 5-mile stretch that was used for the sole purpose of carrying pilgrims to the Mosque of Shah Abdul Azim. Furthermore, 104 miles of the entire system as it then existed was a part of the railways of India and connected Duzdab with Mirjawa on the frontier, while 35 miles of it, linking the oil fields of Musjid-i-Sulaiman with the Karun River and thence with the Persian Gulf, was built by private enterprise and served its own transportation needs. The only important government railroad then in operation was the one connecting the Russian Caucasus system at Julfa with Tabriz, the second largest city in Iran. That line, together with a branch from Sofian to Lake Urmia, is 115 miles long. The remaining 7.5 miles is a narrow-gauge line between Resht and a point on the Enzeli Lagoon whence freight



GLIMPSES OF PARTLY FINISHED WORK

The picture immediately to the left shows the station at Abbas-Abbad, north of Teheran, with a tunnel in the center and a bridge across a chasm at the upper left. The almost insurmountable nature of the country from the standpoint of construction is illustrated at the lower left where native workmen are seen building a service road in the Gadouk Mountains. At the lower right is a suspension bridge that connects service roads on either side of the Ab-i-Diz River. In the center is the Parou Bridge under construction.



PROFILE OF TRANSIRANIAN RAILROAD

is transferred by water to the Port of Pahlevi on the Caspian.

For intercommunication, main dependence was placed upon highways or, better, roads, for the best of them were of the type known as metalled—in this case of stones thrown loosely on the surface and compacted by traffic. Next in point of mileage were the partially metalled roads, next the unmetalled roads passable for light motor cars most of the year but sometimes with difficulty, and, last, the natural caravan tracks. These converged from the four corners of the empire upon Teheran, putting it in touch with all the principal cities in the country and, by rail and water, with the world.

These bare facts, however, do not tell the story of what vehicular traffic has meant and still means in Iran with her formidable mountain ranges and vast desert region which stretches from the northwest to the southeast—from the Elborz Mountains near the Caspian Sea to the arid ranges along the Persian Gulf. Up to the present, incoming and outgoing freight has been handled almost exclusively at the Port of Khorranchahr, on the gulf coast, which is more than 683 miles away from Teheran. The first 186 miles of that journey is through flat, almost desert land, which is impassable during the rainy season of the year. Next it is necessary to climb up and across the Zagros Mountains with their many lofty peaks—the road reaching a maximum altitude of 8,500 feet. In the wintertime, when the passes are snowed under, communication is apt to become difficult and even impossible.

A certain amount of the exports and imports go through Bender Bushire and Bender Abbas, likewise on the Persian Gulf, and, latterly, also through Pahlevi and thence through Soviet Russia. Passenger traffic to and from Europe is about equally divided between the Baghdad-Kermanshah-Teheran-Hamadan route and the Soviet Russia-Pahlevi-Kazvin route.

Since work on the transiranian railway was started, two new ports have been created: one at Bender Chah on the Caspian and at the northern terminus of the line and the other at Bender Chapour on the gulf and at the southern terminal. The latter is a fine natural harbor that is protected from all winds, and will undoubtedly become the principal port on that body of water. In fact, it is already handling as much cargo as its present incomplete equipment will permit. Goods unloaded at Bender Chapour go thence via Ahvaz to Salehabad, from which point motor trucks distribute it throughout the country.

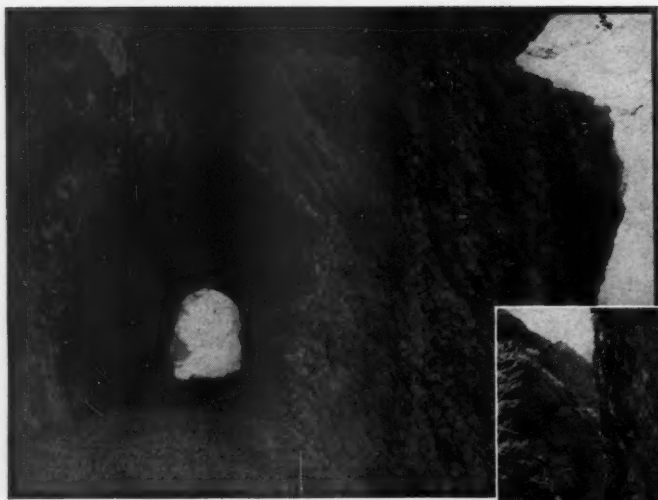
The railroad will have a length of approximately 808 miles. The northern section between Bender Chah and Teheran will be 284.5 miles long, and the southern section extending from the capital to Bender Chapour will be 523.5 miles. On its way through Iran the route passes through numerous communities and regions varying greatly in character, climate, and altitude. Starting at the Caspian Sea and traveling south it first traverses for a distance of 79 miles a fertile plain in the Province of Mazanderan. This district is given over to the cultivation of rice, and supplies sufficient to meet the country's needs. Next it goes through the narrow and steep Valley of Talar before negotiating the rugged Elborz Mountains.

In crossing this range the engineers encountered great difficulties. They found it necessary to excavate many tunnels, spiral in part and sometimes doubling over on themselves, to bridge rivers, to carry viaducts across deep gorges, to build retaining walls to protect artificial tunnels—in short, to do all the heavy and widely diversified work generally required in blazing a right of way through such territory. To reach the highest point in the range—the Gadouk Pass which lies 6,890 feet above sea level—as many as 75 tunnels had to be constructed. The longest of these, as well as of the entire railway system, is the Gadouk Tunnel of about 9,514 feet. This tunnel was completed in 1935.

In the Elborz Mountain section, the railroad rises 4,593 feet on a continuous grade of approximately 28 feet per 1,000, and while the distance from one end of this stretch to the other is but 15.5 miles measured on a direct line, the actual distance covered is 34 miles. From a scenic standpoint this part of the system will be outstanding; and in panoramic grandeur and in boldness of construction will be a worthy rival of the St. Gothard railway in the Alps.

DRIVING A TUNNEL

There are more than 225 tunnels throughout the entire line, of which approximately 150 are in the southern section where this picture was taken. It shows the top and bottom headings at a tunnel portal. Drilling is done chiefly with R-39 "Jackhamers." Solid forged steel was formerly used exclusively, but "Jackbits" are now being employed with great success. The average advance per drilling round is 3½ feet, and four rounds are usually drilled in 24 hours.



DIFFICULT GOING

Sections 4 to 12, inclusive, in the southern part of the line, traverse the exceedingly precipitous Zagros Mountains. There access to working points was first gained on foot or by muleback: later by trucks that travel 10-foot-wide service roads. The building of these roads was a gigantic task in itself, one of them costing $250,000. The pictures show typical conditions. At the upper right of the tunnel, above, will be noticed a notch cut in the rock. This marks the path of the first attempt to round the projection. However, when the workmen reached a point from which they could see ahead, they were confronted by a vertical cliff that defied further progress. Accordingly, they were forced to retreat and tunnel through the mountain.

After descending the southern slope of the range, the road continues on its way for 49.5 miles through the Hableroud Valley. This brings it down to the Central Iranian Plateau and 79 miles away from Teheran. With the exception of the 31 miles nearest the capital, which area is populated and well cultivated, the last lap of the journey to the southern terminus of the northern section is through uninhabited and barren land. In April of this year 205.5 miles of this part of the system, from Bender Chah to Binekouh, was opened to traffic.

Tracing the route of the southern section, with Bender Chapour on the Persian Gulf as the point of departure, the right of way cuts through the vast Plain of Khouzestan in a straight line for 156 miles. In days gone, this was a rich and fertile region: today, however, it is practically a desert waste because river courses have changed and dams and other irrigation schemes are in ruins. From Salehabad, near the ancient Town of Dizful, the road starts to climb the southern slope of the formidable Zagros Mountains—an almost insurmountable barrier. From there on the line follows the Ab-i-Diz River, crosses it at the point where it meets the Ab-i-Cezar, one of its tributaries, and then continues along that stream, within the entire distance of 93 miles running through a series of long tunnels and over big bridges. The section involved the building of about 150 tunnels having an aggregate length of 37.25 miles, and constitutes one of the greatest pieces of railroad engineering ever attempted. Thence, after passing through the towns of Sultanabad and Koum—the latter one of the holy cities of Iran—the railway traverses flat countryside that is partly arid and partly fertile, finally reaching Teheran.

As previously mentioned, the construction of the transiranian railroad started in 1927. By 1933 nearly 235 miles of it had been finished: 156 miles between Bender Chapour and Salehabad in the south and 79 miles between Bender Chah and Chahi in the north. In the beginning the work was in the hands of an international syndicate of contractors, but it was subsequently taken over and continued by the government.

To speed up operations and to assure the completion of the undertaking according to schedule, the imperial government in May, 1933, signed a contract with the Kampsax Consortium, an affiliation of two Danish engineering companies—Kampmann, Kierulff & Saxild, A.S., and Saabye & Lerche, A.S.,—and the Swedish firm of Nydqvist & Holm. That contract stipulated that the northern end of the railway was to be finished by May, 1937, and the project in its entirety two years later.

To simplify matters, the route has been subdivided into many sections or lots, as they are locally called. These have been awarded to Iranian and European contractors invited by the Kampsax Consortium to tender bids, the companies offering the highest discount rate on a set of prices established by Kampsax getting the contracts. The latter are executed under the direct supervision of the consortium. At the present time work is in progress on about 25 lots involving an outlay of approximately $67,000,000. Lots 1 and 2 have been finished, Lots 3, 4, and 12 have been taken over, and on Lots 5 to 11 inclusive operations are in full swing. The part of the line between the beginning of Lot 4 and the end of Lot 12, which is in the south, is known as the Canyon Section because it traverses no less than ten canyons.

Lot 4 in Canyon No. 2 was the first in the Canyon Section to be put under construction. It was there that labor received its initial training in the handling of rock drills, the men's unfamiliarity with those tools being just one more thing to contend with in an already difficult situation. The region being mostly uninhabited, little was known of the climatic conditions, in consequence of which the first summer on the job was a particularly trying one. For three months on end the temperature in the shade is rarely below 112°F., with a maximum of 135° and little relief at night because the heat absorbed by the walls is such as to prevent any appreciable drop in

RUGGEDNESS

These views give an idea of what confronts the contractors. At the left is a canyon in the Zagros Mountains as it looked in April, 1935, before a service road was built through it. In the center is a view of a tributary creek running into Canyon 5 and of a bridge spanning the service road that traverses it. At the upper right is visible part of a portable compressor that was hauled to its location along a ledge barely 5 feet wide. Above is seen the Ab-i-Diz River issuing from Canyon 2, after which it immediately widens.

temperature normally to be expected after sundown. Coupled with the lack of adequate means to provide for the comfort of the workers—there was no ice available that summer—native labor was reduced to about one-fourth of the original force by the men quitting, while the European foremen, supervisors, and engineers had to be sent to the hills at regular intervals in order to recover from exhaustion brought on by the heat.

Until operations got underway, access to the Canyon Section was partly by foot and partly by muleback. To assure an adequate flow of supplies and materials to the working camps it was necessary to build service roads for truck traffic. These had to be cut in precipitous and rocky mountainsides, sometimes taking the form of half tunnels and other times of full tunnels. The most difficult as well as the most costly was that in Lot 6, Canyon No. 4. It involved an expenditure of approximately $250,000. Canyon No. 4 is about 2 miles long and has almost vertical walls rising to a maximum height of about 2,624 feet.

Service roads throughout the Canyon Section are 10 feet wide and have turnouts every few hundred yards to permit trucks to pass each other. The fact that some of these gorges were well-nigh impassable added greatly to the work of the roadbuilders. They never knew what they were up against: they literally had to feel their way along, not knowing what was around the next corner. They had to proceed cautiously to prevent accidents and, possibly, death from landslides and falling rocks. This applied to all the service roads, but particularly to that in Lot 6. At one point where this road was being excavated in the steep canyon wall, the contractor had to retrace his steps and carry it through a tunnel because on reaching a corner that gave him a view of what lay ahead he discovered that the rocky face was cut away to such an extent that he could not proceed. One of the accompanying illustrations shows the site with the abandoned and the new course.

In the southern section, on which work is now mainly centered, the R-39 "Jackhamer" is the favorite drilling machine. Several hundred of them are in operation. It was deemed advisable to standardize on this tool for a number of reasons, and primarily because inexperienced labor only was available; because it took six months to gain access to some of the lots; because of the 3-year time limit set for the completion of any one of the lots; and because material cannot be delivered in much less than six months. Of late, "Jackbits" have played an important part in the drilling which was previously done mostly with 4-point cross bits on ⅞-inch hollow hexagon steel. The average progress per round has been about 3 feet 6 inches, and four rounds are generally fired in 24 hours.

The tunnels vary considerably in length. Most of them range from about 1,300 to 2,000 feet, but many are more than 3,000 feet long and a few exceed 6,500 feet. The longest in the southern section is in Canyon No. 4, where it was excavated in its entirety on the opposite side of the service road. It has a length of 7,710 feet and was advanced from four headings of which two were approached from an adit that was driven close to the center of the tunnel line. The air supply for the latter tunneling operations was furnished by four Type POC-1 direct-connected, oil-engine-driven compressors. Two of these, which it had been possible to transport across the Ab-i-Diz River, were set up one at each tunnel portal, while the other two furnished air for the headings driven from the adit. In this case the air was piped across the canyon.

Just what has been required in the way of rock drilling in the Canyon Section can perhaps be better appreciated when it is known that more than 75 compressors, both stationary and portable, have been in service on Lots 4 to 12 supplying air for the "Jackhamers" and for other lesser needs. Popular among them for heavy duty have been the POC-1 and POC-2 machines of the Ingersoll-Rand Company, as well as its ER and ES compressors belt driven by PO oil engines, while Type 40

CONSTRUCTION SCENES

At the left are buildings housing compressors and other machinery at the junction of two contract sections in the southern part of the line. More than 75 compressors have been employed there in the construction of what is called the Canyon Section. Note the complex folding of the rocks. Persia is known to have valuable mineral deposits, but their development has lagged because of the lack of transportation facilities. At the right is a bridge that carries a service road across a river. The stream rose 6 feet in less than two hours on March 31, 1936.

two-stage, air-cooled gasoline or oil-engine-driven units have served for the lighter work.

The problem of cooling water for the compressors has been a difficult one. In the summertime, stationary units have had to run well-nigh continuously 24 hours a day with a cooling-water intake temperature of approximately 180°F., and with no means available for reducing this temperature economically. The PO engines and the ER and ES machines have proved themselves equal to these abnormal conditions. The portables on Lot 4 have often operated in the hot sun for days on end, doing what was expected of them with little maintenance. In most instances no decarbonizing was done until after the compressors had had about a year of this grueling service.

The remainder of the southern section is less spectacular. Contracts for the stretch from the end of Lot 12 to Koum have been awarded recently, and work towards Koum from Teheran through the Central Iranian Plateau is already in progress. In the latter case there will be little if any tunneling because of the flatness of the country.

As is to be expected on a project of this kind and magnitude, everything has been done properly to house and to look after the sick and injured. Modernly equipped hospitals have been centrally located and, in addition, dispensaries and first-aid stations have been set up at convenient points. There are about fifteen ambulances for the transport of patients; and the entire staff of Iranian doctors, assistant doctors, and orderlies numbers about 500. The medical service is under the direct control of the Kampsax Consortium.

At the present time between 40,000 and 50,000 men are employed on the construction of the transiranian railroad, and of these about 10 per cent are foreigners who are engaged as foremen or in special work. The monthly cement requirements are 10,000 tons, and around 100 tons of dynamite are used each month. The total cost of the undertaking has been estimated at $150,000,000.

Many nationalities—including Iranians, British, French, Germans, Italians, Belgians, and Greeks—are at present represented by the contractors on the job; but despite that fact schedules have been maintained and the program is being carried out as planned. The activities of the Consortium in Iran are under the direction of Kampmann, Kierulff & Saxild with Mr. Saxild, director general, in charge and E. Kayser and H. K. Wright, engineers, serving as directors. The Kampsax Consortium acts as consultant and accredited agent for the Imperial Government of Iran and has done all the surveying, planning, and incidental preparatory work.

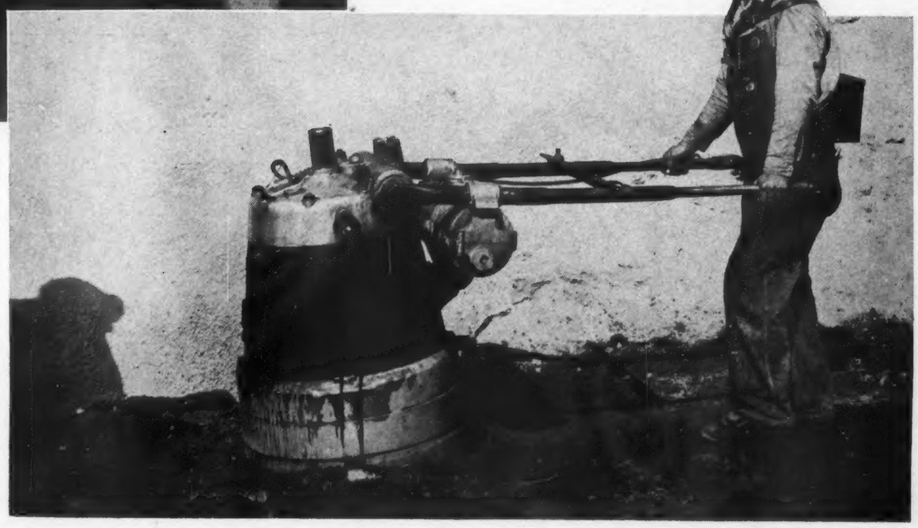
On the southern section of the line, the stretch between Bender Chapour and Galeh Sheikh is in operation and is now given over to combined passenger and freight service, the trains being drawn by oil-fired steam locomotives. Because of the proximity of the oil wells at Musjid-i-Sulaiman and of the Abadan refinery, and also because this is the only kind of fuel available in the district, oil will be used at least on the southern end of the railroad. Two diesel-electric rail cars have been ordered in Sweden, and this would lead to the belief that the government has given serious consideration to the question of motive power.

Passenger traffic between the Persia[n] Gulf and Teheran will undoubtedly in[crease] as time goes on and as the countr[y] is developed; and until it is such as t[o] warrant fast service with regulation train[s] rail cars would seem to be the ideal mea[ns] of transportation both from the standpoi[nt] of speed and economy. They require litt[le] attention; are available at a moment['s] notice; and can run for months on en[d] without returning to the shops for overhau[l]. The fuel they consume, in weight, is le[ss] than that needed to operate oil-fired stea[m] locomotives, and this is an importa[nt] factor where fuel has to be hauled gre[at] distances. In addition, suitable water f[or] the boilers is somewhat scarce along t[he] line.

What has just been said applies in a w[ay] also to future freight trains. The indic[a]tions are that diesel-electric locomotiv[es] will be called upon for this work. Th[ey] burn, power for power, only a fraction [of] the fuel required by oil-fired steam loc[o]motives; and in addition to the extra c[ost] for fuel incurred in the case of the latt[er] there is the matter of its delivery as well [as] storage at convenient places *en route*. A[s] as to the question of water, the needs of t[he] diesel-electric in this respect are small [as] compared with the steam locomoti[ve]. Finally, the latter must go to the sho[ps] fairly frequently for cleaning and ov[er]hauling, while the diesel-electric, as h[as] been already mentioned, can remain [in] service for months at a time.

Bearing all these facts in mind, it is o[b]vious on the face of it that the adoption [of] oil-electric's would mean fewer locomotiv[es], fewer engineers, a reduced maintena[nce] force, lower fuel cost—in short, econom[y] all down the line.

Heavy-Duty Tamper for Work in Close Quarters



"LEAPING LENA"

In these illustrations the Delmag Frog, as it is designated by the manufacturer, is shown in the lowest and in the highest operating position. It consumes about 2 quarts of gasoline an hour, and carries enough fuel in its tank to keep it going under normal conditions for half a working day. The operator guides and controls the movements of the heavy machine by means of the hinged handles and the pushbutton that can be seen beneath his right-hand thumb in the picture above.

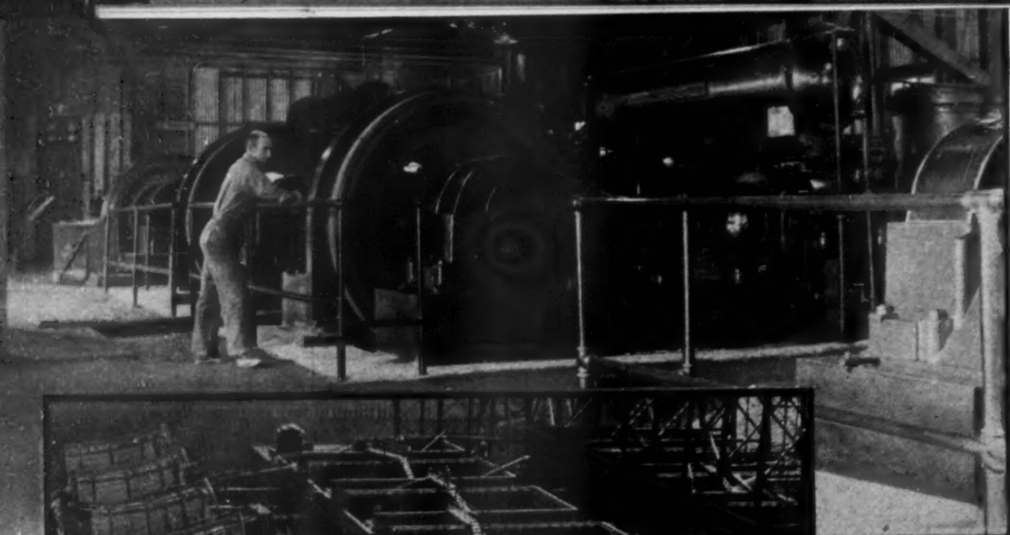
IN USE on the San Gabriel Dam No. 1, now under construction for the Los Angeles County Flood Control District, is an odd piece of equipment—a mechanical frog that hops around under the pressure of an electric button. The men on the job, true to type, have dubbed it "Leaping Lena." Its function is to compact earth fill that is too close to cut-off walls, abutments, and the like for the operation of regulation sheep's-foot rollers.

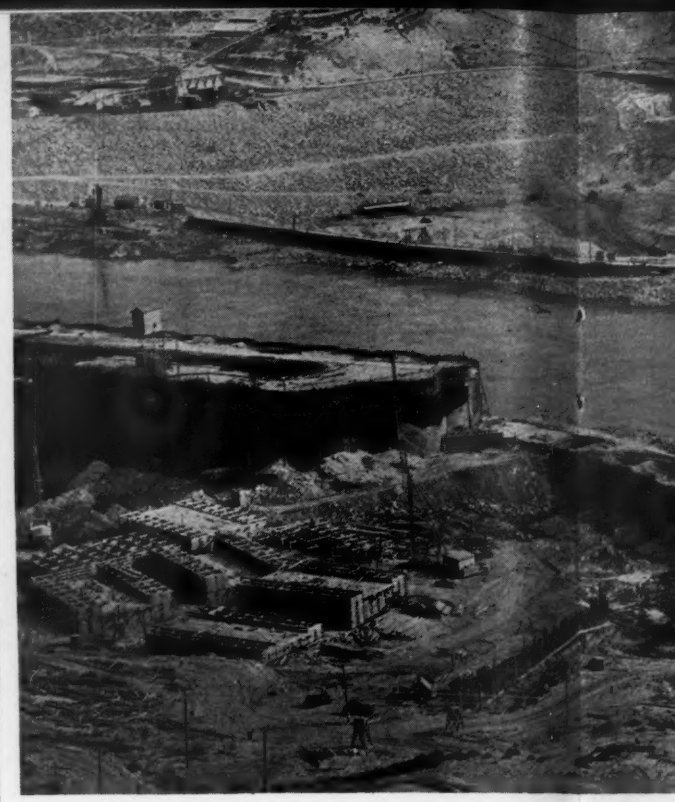
The rammer or tamper, as the illustrations show, is in the shape of a truncated cone provided with handles and a gasoline tank, which has a capacity of 2 gallons. It is really a 4-cycle, single-cylinder internal-combustion engine that is capable of lifting itself bodily and of moving forward at the same time under the impulse of a succession of explosions. These are controlled by the operator by means of the aforementioned pushbutton, which is at the end of the right-hand handle within reach of his thumb. The necessary electric batteries and igniter are carried in a case on his back.

The tamper itself consists of an upper and a lower part or base weighing, combined, about half a ton. To set it going, it is necessary first to push a lever introduced in the piston rod, which projects above the top of the machine. This causes a piston spring to be compressed, thus raising the piston in several successive 3-inch lifts and bringing pressure to bear on another spring and on the air-and-gas mixture in the combustion chamber. With the explosion of this charge the upper part of the machine is lifted. This constitutes the first cycle or stroke, during which the piston spring is stretched. Next, through the subsequent contraction of this spring, the base is raised clear of the ground. This is the second cycle, in the course of which the waste gases are exhausted. During the reaction that follows, the spring again expands, causing a fresh explosive mixture to be sucked into the combustion chamber. At the end of this third stroke the rammer strikes the ground heavily. "At the same time that it delivers this blow," to quote Paul Baumann, junior assistant chief engineer, Los Angeles County Flood Control District, "inertia coupled with the impact causes maximum compression of the explosive gases in the combustion chamber, thus completing the fourth cycle and putting the equipment in readiness for the next ignition spark. The operator has to learn to observe the cyclic positions of the tamper so he can time the explosions correctly. This is not difficult, and can be learned quickly by an intelligent laborer."

The maximum capacity of the mechanical frog is 50 jumps a minute, each time leaping upward approximately 9 inches and forward about the same distance. To aid the latter movement, the bottom of the rammer, which has a diameter of 30 inches, slopes slightly downward from front to back. Airplane gasoline serves as fuel because it gives better results than that commonly used; and the records show that the machine can cover an area averaging approximately 3,000 square feet in an hour.

On the section of the San Gabriel dam site where the tamper is operating, the fill varies from a finely decomposed granite to a sandy loam in which are found occasional pieces of rock not exceeding 5 inches in diameter. This material is compacted in layers each 9 inches thick. It weighs about 90 pounds per cubic foot in the dry state and when freshly spread, but after the "Leaping Lena" has gone over it once it averages 115 pounds per cubic foot, which is sufficient in the case of the work in question. Further tamping would, of course, proportionately increase the weight, and, according to the manufacturer, the Delmag Company, Esslingen, Germany, three trips of the rammer over sand fill 2½ to 3 feet thick made it as compact as was the original water-laid deposit 13 feet below it.



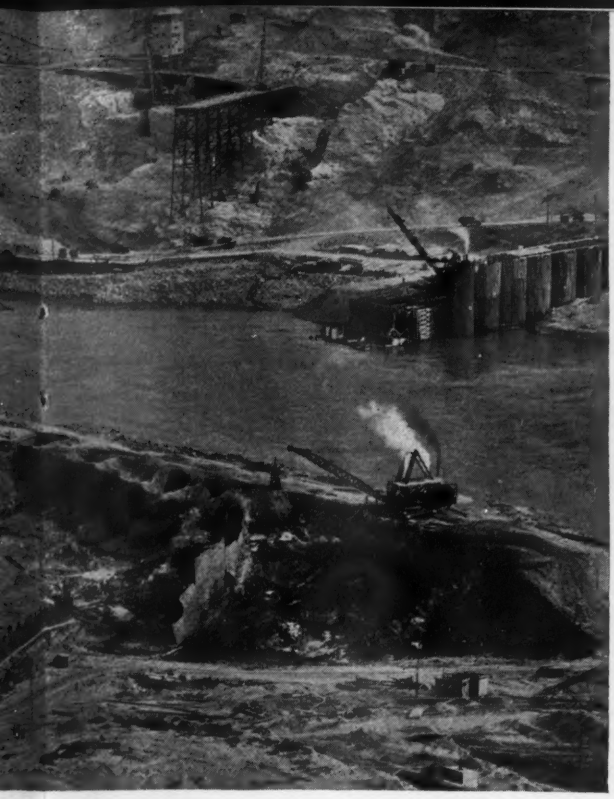


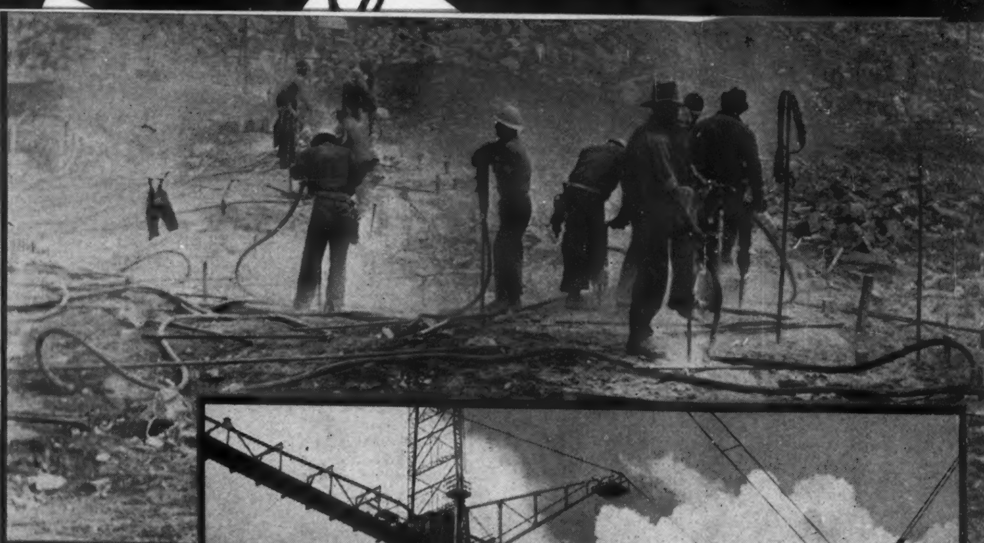
Camera Studies at Gra

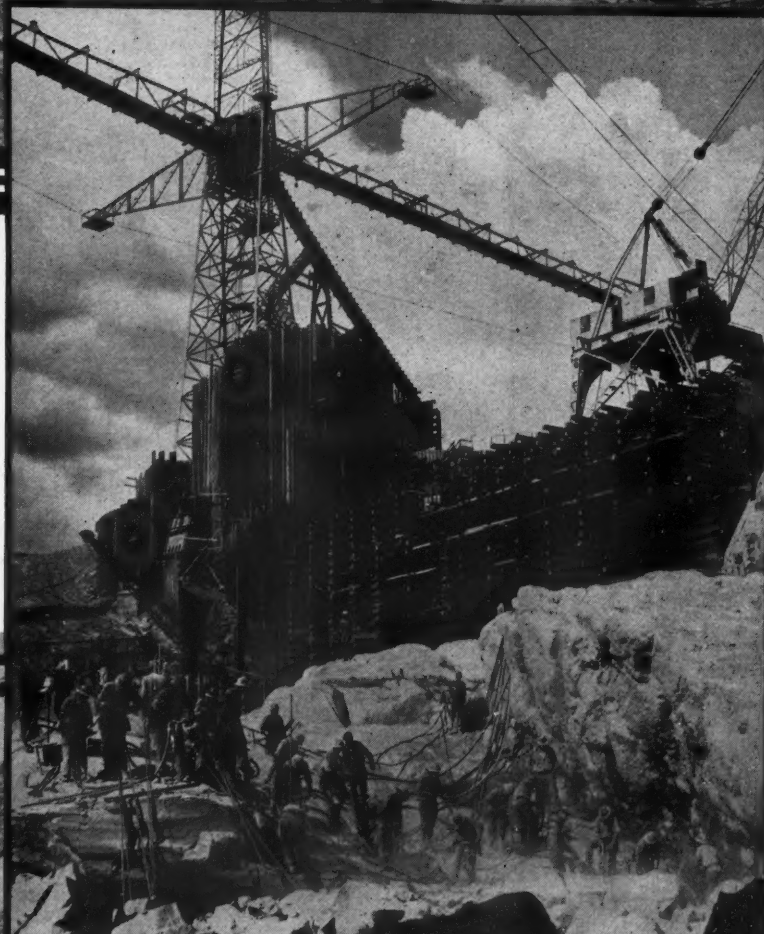
AT THE right is a view across the west-cofferdam area toward the west abutment, with approximately 1,500,000 cubic yards of concrete in place. The white structure at the far end of the suspension bridge is the west-side concrete mixing plant. Its four 4-cubic-yard mixers were originally rated at 6,000 cubic yards per day, but their daily output has been worked up to more than 8,400 cubic yards. The concrete is run into 4-cubic-yard buckets on steel flat cars, hauled out on the trestle by 10-ton diesel-electric locomotives, and picked up by one of eight cranes for placing in the forms below. With only one mixing plant operating, concrete deposition has reached a maximum rate of 1 cubic yard every 10½ seconds. A similar plant on the east side will be used later.

Above—Reinforcing steel being placed around the nine 18-foot-diameter penstocks that will extend through the dam to the west-side power house. The two power plants on either side of the central spillway will each contain nine 120,000-kva. generators, driven by 150,000-hp. turbines, and three 7,500-kva. station units. The average operating head will be 335 feet.

Top, left—Interior of one of the two compressor houses. Three Type PRE 2-stage machines are shown.







t Grand Coulee Dam

THE picture at the top, center, was taken looking across the Columbia River toward the east abutment. At the upper right the shore arm of the cross-river diversion dam is reaching out into the stream. A similar arm will cross further downstream, thereby inclosing the central area so that it can be pumped out and excavated preparatory to pouring concrete. The construction of these barriers involves the building, launching, and sinking of the largest timber cribs ever made. By spring the river will flow through openings left in the concrete now being poured in the west-cofferdam area to the left out of range of the camera. At the top center is the east-side concrete mixing plant and, extending out from it, the beginning of the trestle that will be used for placing concrete.

Above—The intensity of rock drilling at Grand Coulee is illustrated in this picture. Approximately 130 hand-held drills were at work in September, biting away at the granite base and abutments. In addition, drifter drills on tripod and wagon mountings were putting down deeper holes for the introduction of grout so as to seal any openings in the foundation rock.

Top, right—A close view of drillers working in the east cofferdam.

Let's Drill an Oil Well

R. E. McCollum*

and

W. L. Clingman†

SEVENTY-SEVEN years ago last August 27, Edwin Laurentide Drake completed the first successful oil well in the United States and thereby started one of the greatest industrial developments the world has ever known. Nearly $15,000,000,000 is now invested in the various branches of the petroleum industry in this country, and 2,000,000 persons are employed by it. Colonel Drake (the title was bestowed by an employer who thought it would impress those whom Drake contacted) spent his last years as a pensioner of the State of Pennsylvania, but he laid the groundwork for some of the nation's greatest fortunes. The forests of derricks that rise in certain parts of the country, the huge refineries, the network of underground pipe lines, the fleets of tank ships, the strings of railroad tank cars, the droves of tank trucks, the myriad of filling stations and roadside gasoline pumps, and even the cavalcade of motor cars that speed the highways are all consequences of his momentous pioneering effort.

Drake's well was put down on the bank of Oil Creek near Titusville, Pa. For some years afterward, Pennsylvania was the principal source of petroleum. Even now it ranks high as regards the quality of its oil, but other sections of the country have far outstripped it with respect to volume of production. Curiously enough, the second commercial oil field was found in far-off Colorado, then an outpost of civilization. A. M. Cassidy brought in a well near Flor-

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Hall & Briscoe, Inc., and F. C. Hall, Inc.
† Superintendent, Fain Drilling Company.

OIL-FIELD SILHOUETTE

A steel derrick, in the Playa De Ray field of California, with the ends of drill-pipe joints jutting out in the foreground.

Ewing Galloway Photo.

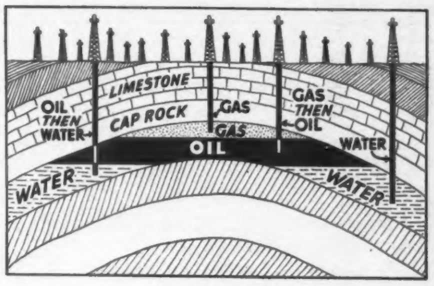
ence in that state on January 8, 1863, only four years after Drake's initial strike. The field still produces a few barrels of oil a day.

The nation's present daily output of petroleum, which is restricted by the Interstate Oil Compact Commission in proportion to the gasoline consumption, is around 3,000,000 barrels of 42 gallons each. Of that stupendous total, Texas contributes approximately 1,200,000 barrels; California and Oklahoma nearly 570,000 barrels each; Louisiana 235,000 barrels; and all the other states the remainder of 425,000 barrels. The stock of crude oil on hand stands currently at around 300,000,000 barrels, or roughly 100 days' domestic production. Meanwhile there is a continual hunt for additional oil fields. Prospecting activities abated during the depression, but have been redoubled now. The modern geologist makes use of geophysics to aid him in finding underground stratigraphic structures that are favorable to the formation and retention of oil. In September, 260 geophysical crews were reported at work at a monthly cost to the oil companies that employ them of more than $1,000,000. About 75 per cent of them use the seismograph method. The demand for specialists in this new science is so great that trained men are said to be virtually unobtainable.

Increased gasoline consumption, which has accompanied the upturn in automobile buying, has provided the stimulus for the step-up in petroleum production. The 1936 domestic gasoline demand is estimated at slightly less than 20,000,000,000 gallons, an increase of 9 per cent over that for 1935. Only two states—North Dakota and South Dakota—consumed it at a lower rate than a year ago. The economic aftermath of the drought is held responsible for that decline.

The man that started all this activity was little qualified by training to drill an oil well. He had previously earned a livelihood chiefly as a drygoods salesman and a railroad trainman. While in New Haven, Conn., he met a banker, James M. Townsend, who induced him to invest his entire savings of $200 in a company whose business it was to extract "rock oil" from Pennsylvania shales. A little later, Townsend sent Drake to Pennsylvania to make some investigations. There he conceived the idea that the earth could be made to yield oil through a hole, and his drilling venture followed. His efforts were ridiculed, and the well was called "Drake's Folly." Because of his unfamiliarity with mechanical things, Drake hired William A. (Uncle Billy) Smith as driller. The well came in at a depth of 69½ feet.

Since then, the probing of the earth's crust has gone deeper and deeper, and some wells have been put down nearly 12,000 feet. Even greater depths can be reached, but at a cost so great as to make the operations come more under the head of gambling than of good business. Two "dusters" or dry holes recently abandoned in California are reputed to have cost their promoters about $600,000 each. Even where extremely deep wells strike oil, production must be prolonged for years to show a profit.



HOW OIL OCCURS

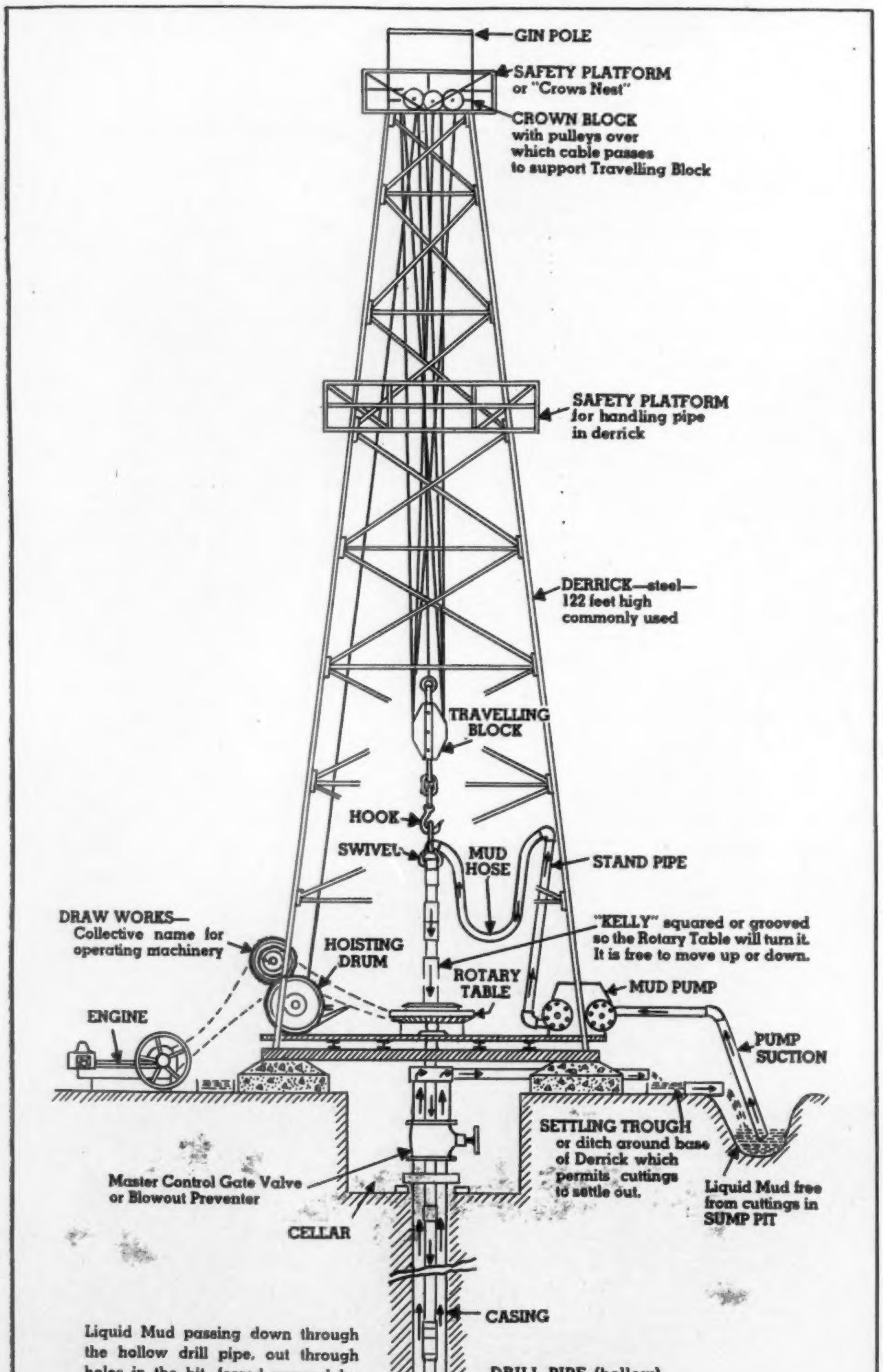
An ideal anticlinal structure or dome, showing how the location of a well determines whether it will strike oil, gas, or merely water. Eventually the water rises and fills the space formerly occupied by the oil and gas. The drawing is reproduced from an American Petroleum Institute publication.

Up to the turn of the century all oil-well drilling was done with cable tools. By this method a chisel-like bit is suspended by a hempen rope from the end of a walking beam that moves up and down, thereby alternately raising and dropping the tool upon the rock at the bottom of the hole.

RUNNING CASING

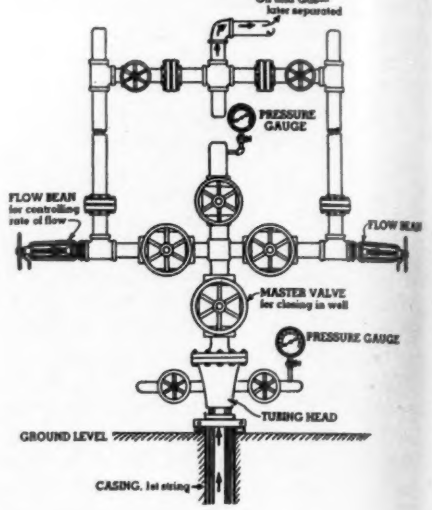
To prevent the walls of the hole from caving, to seal out water, and to provide a means of controlling the flow of oil and gas, seamless steel tubing, termed casing, is placed in the hole and set with cement. Casing comes in 30-foot lengths, a number of which can be seen standing in the derrick in the background. A section of casing has been lowered through the rotary table where it is held fast with three steel wedges while another section is screwed on to it. The two are then lowered 30 feet and the operation is repeated. This continues until sufficient casing has been assembled to reach to the bottom of the hole. A completed well contains several strings of casing, the smaller arranged concentrically within the larger.

Ewing Galloway Photo.



ROTARY-TYPE DRILLING RIG

This drawing, which was prepared from information furnished by the American Petroleum Institute, shows the components of a modern rotary drilling installation and illustrates the various parts they play.



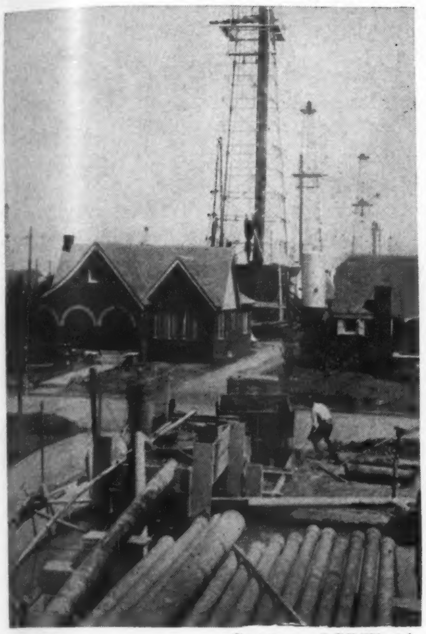
"CHRISTMAS TREE"

The control apparatus that prevents wells from flowing wild and perhaps catching on fire. The name was applied because of the resemblance of the complicated assembly to the trunk and branches of a tree. The hook-up varies according to the well pressure.

In 1901 the rotary method was introduced and is now used almost exclusively for deep-hole drilling. The rotary rig imparts a twisting motion to connected drill pipes and to a toothed rock bit affixed to their lower end. Details of the procedure will follow.

One of the most spectacular oil fields of the present day is in Oklahoma City, the capital of Oklahoma. A veritable orgy of "town-lot" drilling is underway there on a scale that has not been witnessed since Long Beach, Calif., property owners succumbed to the lure of oil royalties a few years ago. What happened in Oklahoma City is familiar to newspaper readers, but will be recounted here briefly. The field was opened in December, 1928, the initial well being brought in a few miles southeast of the city limits. As additional wells were drilled the proven area moved northwestward. By 1931 the known productive area was 8 miles long and 3 miles wide, and had been extended to a point about a mile east of the business district and 2 miles south of the state capitol. Within this area were about 1,000 wells. At this stage, the depression halted developments, although the limits of the field had not yet been defined.

As the mists of economic uncertainty cleared and the price of oil stiffened, activity was resumed. Many property owners within the municipal limits wanted to throw open their tracts to drilling. Others rebelled, knowing that it would destroy the appearance of the city; reduce realty values greatly; and perhaps not yield returns sufficient to offset these unfavorable factors. After millions of words of argument had been exchanged, for and against the proposition, the city council ordered an election held with respect to opening a certain section to drilling, this being the procedure



Courtesy of Oil Weekly

BACKYARD OIL WELLS

A scene in the Mansion District of Oklahoma City. In many instances houses have been moved to make room for drilling paraphernalia. Operations go on 24 hours a day accompanied by all kinds of noises that disturb the sleep of the residents. Offsetting the destruction and inconvenience is the promise of oil royalties. The standard royalty is 12½ per cent.

provided by law. The vote was favorable, and a crescent-shaped area around the capitol and adjacent state-owned lands was opened for testing.

That was in April, 1935, and in December the first well drilled in the extension came in with a potential yield of 30,000 barrels a day. It was located northeast of the capitol, about 2 miles from the nearest producing well. It was immediately evident that the intervening 2-mile stretch was oil-bearing, and owners of property within it clamored for the privilege of leasing it for drilling purposes. In response to this agitation, another extension was opened by vote in March, 1936. It included the section just north of the capitol and extending southward. A curious fact about these elections is that the entire electorate has the right to vote even though only a part of the city's area is involved.

As a result of the two elections, land was opened on three sides of the capitol and adjoining state property. Gov. E. W. Marland, a former oil-company executive of long experience, knew that the oil would be drained from beneath these zones and demanded that they, too, be given over to drilling. To win his point against objectors, he declared martial law, granted leases that brought the state $400,000 in bonuses, and called out the militia to prevent interference with the drilling operations that were immediately started. During the depression-period regime of Marland's predecessor, "Alfalfa Bill" Murray, these state tracts were sown with oats to make them useful. Now there are ten oil wells on them, and these are expected to net around $500,000 in royalty payments.

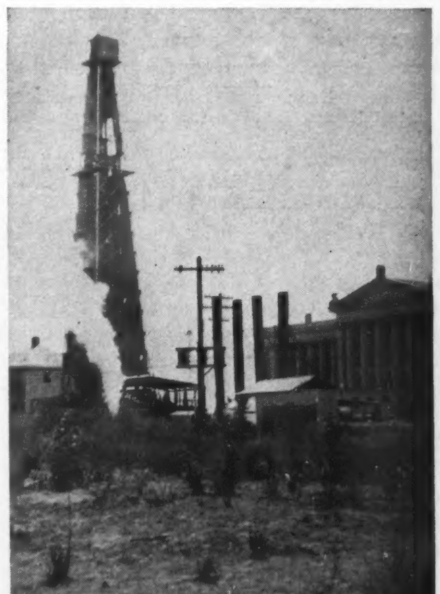
In May, the remainder of the east side of Oklahoma City was added to the open area. Only Lincoln Terrace, an exclusive residential section with $15,000 to $25,000 houses, has escaped invasion by drilling paraphernalia. It is written into the deed to each piece of property in this subdivision that only residences can be erected there. The legality of this clause is now being tested, and some loophole may be found whereby even the city's most beautiful section may become a part of the oil field.

In a spirit of humor, oilmen have appropriately named the intracity areas the Capitol District and the Mansion District. Something approaching destruction has been wrought there as a result of the drilling activities. On the day after the March election, 75 locations for wells were made and nineteen slush pits were dug. Within two months 145 rigs were operating, each crowding the tools to the limit in an effort to reach the reservoir of black gold ahead of its neighbors. Lawns were torn up in excavating trenches for pipe lines and power cables. Houses were moved to make way for derricks, boilers, engines, pipe racks, and other essential equipment. Trucks hauling these materials to well locations pulverized pavements. Confusion reigned everywhere. Despite the use of various muffling devices, the dissonance of the drilling symphony disturbed the slumbers of the householders.

The procedure followed by the property owners in each block was to band together and give a blanket lease covering their holdings. These were readily salable at high prices, the average lot bringing a bonus of from $300 to $1,000 for signing a lease which, in addition, provided for a royalty payment of 12½ per cent or more of the value of all oil that might be recovered. Town-lot drilling is notoriously wasteful, because of the great division of ownership. Everyone wants his land drilled first, for delay means that adjoining wells will withdraw a goodly portion of the oil from beneath it. The average spacing of wells in Oklahoma City is one to five acres, whereas orderly development of the field would call for one to ten or twenty acres. Each well that is put down releases some of the precious gas that serves to push the oil to the surface. The sooner the gas supply is depleted the sooner it is necessary to resort to some artificial method of lifting the oil, and the lower becomes the ratio of ultimate recovery to contained oil.

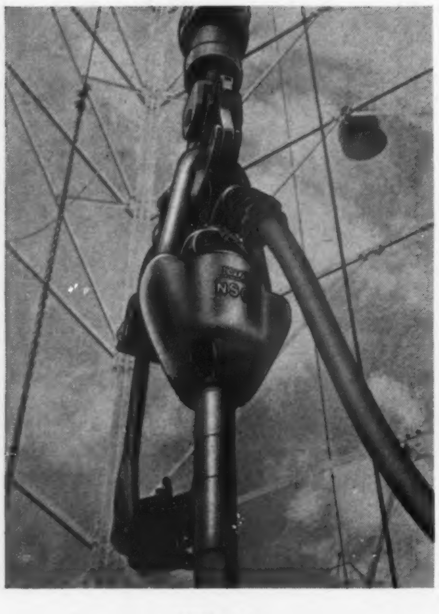
The original wells drilled in the southern part of the Oklahoma City field showed a bottom-hole pressure of 2,600 pounds. Close spacing of wells and failure to control escaping gas dissipated this energy to such an extent that the first well drilled in the Mansion District indicated a bottom-hole pressure of but 650 pounds. By November 20 the pressure had dropped to around 300 pounds. The lot owners will therefore get only a portion of the revenue that Nature made it possible for them to receive. Thinking oilmen decry these wasteful methods, but they are more or less powerless to prevent them in fields such as this one. The property owners, because of their insistence upon closely spaced wells, are just about as much to blame as are the production companies. Despite the prodigality, wells in the Mansion District have come in with potential yields ranging from 4,000 to 19,000 barrels in 24 hours. These figures, however, mean little in computing their ultimate returns, as production will naturally drop fast.

Going back to the discussion of how a well is drilled in this area, we can say that the procedure is standard and differs from that in other sections only in that the extenuating circumstances call for added speed of operations—operations that even under ordinary conditions are performed virtually with no waste of time. It seems hardly necessary to state that the technique of drilling has undergone revolutionary changes since the pioneer Drake effort. Every detail of the complicated procedure has been subjected to searching study. Every new oil field serves as a laboratory for further research. As a result, equipment, methods, and organization of personnel have been brought to a highly effective stage of development, making possible a



FROM OAT FIELD TO OIL FIELD

When "Alfalfa Bill" Murray was governor of Oklahoma he planted oats on the land surrounding the capitol in Oklahoma City. His successor, E. W. Marland, has found oil to be a more profitable "crop" and has given leases that are expected to net the state nearly $1,000,000. Here is shown a steam-powered drilling rig that is driving a bit toward the productive Wilcox sand, 6,000 feet underground. The statehouse is in the background. The derrick has been boarded up inside to guard against the possibility of oil being sprayed about.



SWIVEL

The swivel holds the "kelly," permitting it to be turned by the rotary table. The swivel is, in turn, suspended by a bail and hook from the crown block at the derrick top. The pressure on the rock bit at the lower end of the drill pipe can thus be lightened, as desired. The hose that slants across the lower right conveys mud from the pump into the hollow drill rods and thence to the bottom of the hole for the removal of cuttings.

coördination of effort that can be likened to the play of a well-coached football team. Lost motion has been eliminated so far as practicable, and the drilling of a modern oil well is essentially a race. A saving in time is a saving in money; and when we consider that it costs as much to put down a single hole as it does to construct a good-sized business building, and that the larger oil companies drill hundreds of wells a year, the importance of drilling a few more feet of hole per day, when taken in the aggregate, will be readily apparent.

The first step in the drilling process is digging a cellar. This is simply a hole in the ground about 10 feet in diameter and 12 feet deep. To give access to the bottom, a stairway is placed on either side of it. Concrete foundations for the derrick are poured at ground level and are in the form of piers set at equidistant points around the hole. The derrick floor is ordinarily about 6 feet above the general level of the area, so that the distance from it to the bottom of the cellar is approximately 18 feet. The derrick is of steel, is assembled in sections, and is 122 feet high. On top of it is installed the crown block, which is a steel carriage supporting pulleys over which pass cables designed for the heavy lifting that is required. Surrounding the crown block is a working platform or "crow's nest." At a point about two-thirds of the distance between the bottom and top is another platform for the handling of pipe in the derrick.

Other essential parts of the equipment are a rotating table, draw works, mud pump, and source of power. Various types of prime movers are used for providing power, but the steam engine still predominates. In the oil field in question, a 12x12 twin-cylinder, heavy-duty engine is in service. It is supplied with steam by three or four boilers. These are rated at 125 hp. each and operate at 350 pounds steam pressure. They consume from 1,500 to 2,000 barrels of water per day, depending upon the load. Draw works is a collective name for the operating machinery. It consists of a line shaft and drum shaft, of three jack posts, and of two brake drums. The cable is wound around the drum shaft and passes from there up to the crown block. The brake drums are at either end of this drum shaft and must be of sufficient size and power to stop and hold loads of 100 tons or more. Accordingly they are 5 feet in diameter and 12 inches wide.

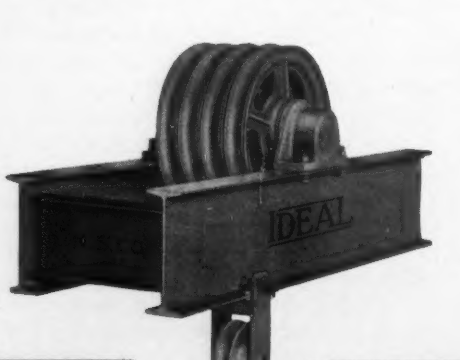
The rotary table, as its name implies, imparts the rotary motion to the bit by turning the drill pipe to which it is connected. The table is a cylindrical slab of steel about 4 feet in diameter. It is mounted, with its flat sides horizontal, in the center of the derrick floor and directly over the drill hole. It is driven by a chain and gear from the draw works.

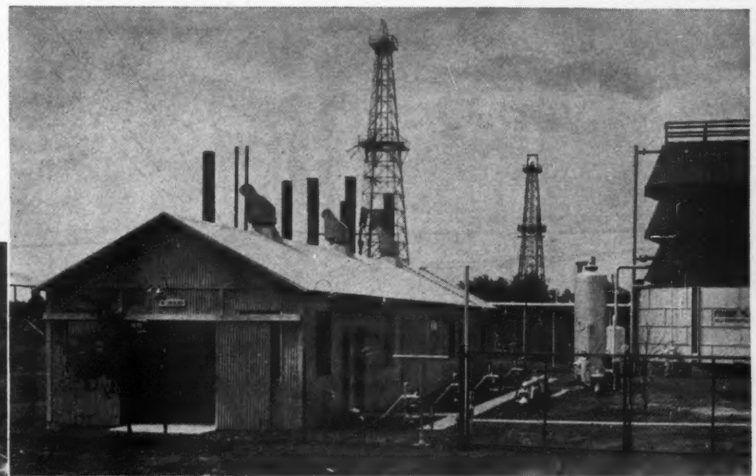
The drilling assembly is made up of the bit, drill pipes, and kelly or "grief stem." The kelly is a steel member of square section, about 32 feet long, and always stays at the top. It extends down through an opening in the center of the rotary table, where it is clasped firmly by clamps which insure that it will turn with the table but which permit it to move up or down. As the hole is deepened, lengths of drill pipe are added to the bottom of the kelly, a section at a time. At the top of the kelly is a swivel and bail. To the latter is attached the hook of the traveling block which is suspended from the fall lines of the cables extending down from the crown block. Thus the string of drill pipe is held at all times while drilling is in progress, and the pressure on the bit can be lessened by taking up some of the weight of the drill pipe. In the Oklahoma City field, 6-inch drill pipe is customarily used. It is made up in 30-foot lengths. It weighs 26 pounds per linear foot and bears at each end a tool joint that weighs 150 pounds.

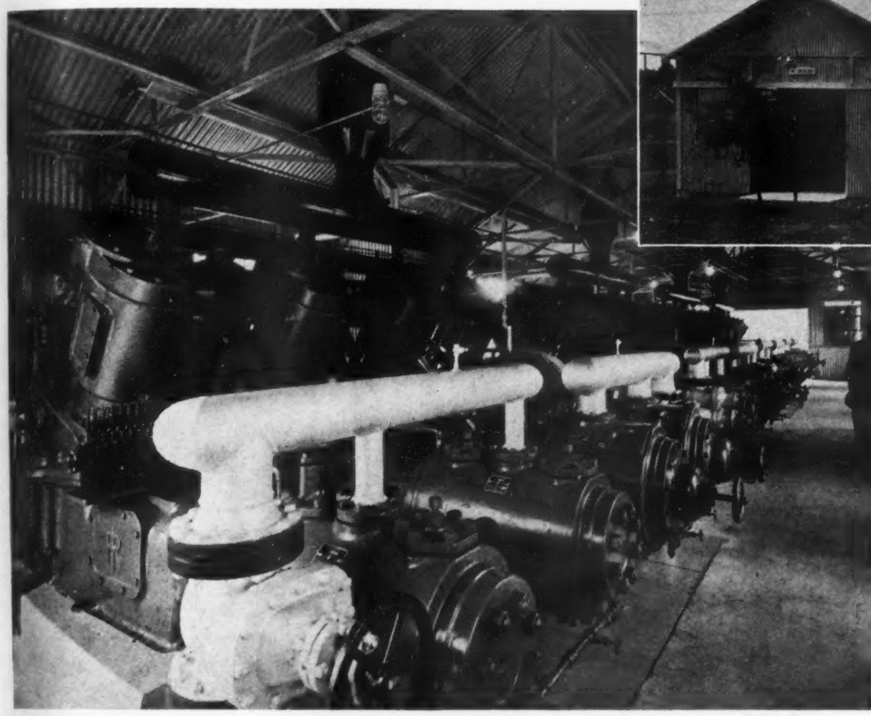
The kelly and the drill pipe are hollow to permit forcing mud down and out through them by way of openings in the bit, the purpose of the mud being to remove the cuttings from the hole. The mud enters the assembly through a hose connection at the swivel on top of the kelly. It is circulated by a mud pump or "mud hog," which is steam driven. This is a heavy reciprocating pump having an 18-inch stroke and a steam cylinder sometimes as much as 12 inches in diameter. Using 350-pound steam, it will develop pressures up to 800 pounds when handling heavy mud.

DRILL-RIG PARTS

The rotary table (lower left) is driven from the draw works by means of a chain that passes around the gear wheel at its right end. The square-sectioned "kelly" extends down through the center of the table and is caused to turn with it, thereby imparting a rotary motion to the drill rods and to the rock bit at their lower end. The center picture shows the crown block, which rests on top of the derrick. A cable extending upward from the draw works passes over its pulleys and thence down inside the derrick to the traveling block. By aid of this tackle hook-up are handled loads of 100 tons and more in and outside of the hole. At the lower right is a steam-driven mud pump which forces mud down the drill pipes, through the bit, and thence back to the surface through the annular space between the drill pipes and the walls of the well. The pictures on this page are shown through the courtesy of the National Supply Company.







GAS-LIFT COMPRESSOR PLANT

Interior and exterior views of the Francis plant of Hall & Briscoe Inc., and F. C. Hall, Inc., in the Mansion District of the Oklahoma City field. It contains four Ingersoll-Rand Type XVG gas-engine-driven compressors. Each unit has eight vertical power cylinders and four horizontal compression cylinders. Two of the latter are high-pressure and two are low-pressure cylinders. The gas, which can be compressed to any desired pressure between 300 and 800 pounds per square inch, is piped down the wells to lift the oil to the surface.

The pump is mounted on a concrete foundation alongside slush pits. There are two of these pits. They vary in size, but average about 30x120 feet and are from 4 to 6 feet deep. The mud is in continuous circulation, down the hole and back to the surface through the annular space around the drill pipe. Before reëntering the slush pits it is passed over a "shale shaker" for the removal of sand and bits of rock which would be hard on the pump. The shale shaker is similar to a jig used in the milling of ores, and is driven by a small electric motor. The mud is maintained at the desired consistency by adding water to it from time to time in the slush pits.

To prevent caving, to shut out water that may be encountered, and to control the flow of oil and gas, seamless steel pipe or casing is placed in the well—the heavy mud that is circulated supporting the walls until the casing has been put in. The size of the casing decreases progressively as depth is attained. In the Oklahoma City field the hole is generally started with a diameter of 22 inches. When down 40 feet, the drilling tools are withdrawn from the hole and 20-inch-diameter casing, which is termed the surface pipe, is run in and "set" with about 75 bags of cement. The setting operation is a specialized job and is performed by companies that do nothing else, the drilling company furnishing the materials. The cementing company uses portable outfits, each consisting of a large 4-wheel-drive truck on which are mounted two pumps for handling the cement grout. After the required amount of cement is pumped into the hole, a wood or rubber plug is lowered on top of it. Mud is next pumped into the hole by the well installation. This serves to force the cement down and to push some of it up around the outside of the casing, forming a gas-tight seal between it and the surrounding earth or rock.

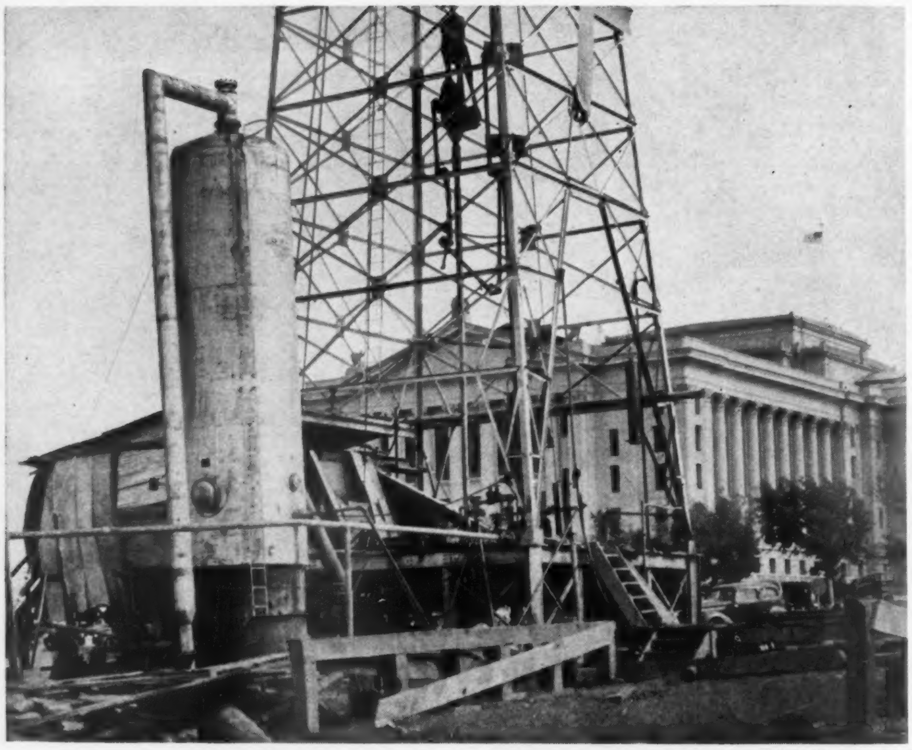
Seven days are allowed for the grout to harden, after which drilling is resumed with a 17¼-inch bit and continued for 1,000 feet. Following that, 13⅜-inch casing is set in the hole with 750 bags of cement. From there on down to a point approaching the oil-bearing Wilcox sand, at a depth of about 6,400 feet, a 12¼-inch bit is used. Then 9⅝-inch casing is set and grouted with 1,500 bags of cement. Each string of casing extends from the top of the hole to the horizon at which it is set. Accordingly, there will be approximately 6,400 feet of the 9⅝-inch size in the hole.

The casing is screwed together, length by length. A section is lowered in the well until its top projects a little above the derrick floor, when it is clamped in the rotary table. Another length is then added and the string lowered. This procedure is repeated until the pipe column reaches bottom. As 9⅝-inch casing weighs 44 pounds a foot, the total weight of this string of pipe is about 140 tons. In order to take as much as possible of this weight off the handling equipment, two float valves help to float the pipe in the well when putting it in.

Drilling proceeds at a fast rate during the early stages of the work. As the hole gets deeper, the formation grows harder and progress is slower. From 30 to 35 bits are ordinarily required in drilling a 6,400-foot hole in the Oklahoma City area.

With the casing set at 6,400 feet, certain other things must be done before "drilling in" to the oil-bearing horizon. A few feet above the floor of the cellar there is installed a huge master control gate that weighs approximately 3,000 pounds. About 2 feet above it is a second one of the same kind. By turning the wheel of one of these valves a steel wedge is forced down across the opening in the pipe to shut off the flow of oil and gas. Naturally, these valves cannot be closed while the drill pipe is in the well because the wedges will not seat, so additional control equipment must be provided. Accordingly, a Shaffer gate is placed above both of them. This is a square steel box having a sectional rubber valve that closes in toward the center from all sides when the control wheel is turned. Because of this action a well can be shut in even when tools or tubing are in the hole.

When drilling in a well in which oil and gas is rising, it is necessary to have a valve within which the square-sectioned kelly can turn. For that reason a blow-out preventer is flanged on the casing above the



Courtesy of Oil & Gas Journal

OIL FROM BENEATH OKLAHOMA'S CAPITOL

Although this well of the Sunray Oil Company with others is located 220 feet from the statehouse, shown in the background, it is actually producing petroleum from beneath the structure. A slanting hole was purposely drilled to make this possible. At the time of its initial test, with the tools still in the hole, the well flowed at the rate of 190 barrels of oil per hour and also produced gas at the rate of 3,000,000 cubic feet per day. The well is about 6,400 feet deep.

three gates. This is in the form of a tee, the arms of which are cylinders about 2 feet long and 12 inches in diameter. In these cylinders are rubber rams that operate partly by water pressure and partly by a manually worked screw element. The rams are constructed so that the kelly can turn in them. With this arrangement it is possible to continue drilling the well deeper into the producing sand and at the same time permit oil to flow out. This whole assembly of control apparatus is commonly termed a "Christmas tree" because of its appearance. Its use virtually eliminates the fire hazard of former days when wells being drilled in not infrequently broke loose. Rocks and sand hurtled upward against the derrick produced sparks that caused the issuing column to burst into flames.

Interposed in the casing head between the Shaffer gate and the preventer is a tee for flowing a well both during and after drilling in. To the center opening in the tee is attached a nipple, about 4 feet long, and at its outward end is another master control gate. This leads to the flow line through which the oil and gas pass to a separator—a vertical tank about 22 feet high and 5 feet in diameter. The flow line enters the latter tangentially about midway of its height—the stream of mixed oil and gas being given a whirling motion. The gas, being lighter than air, goes out of the top of the tank through a vent line to atmosphere, or it is piped to an extraction plant where its gasoline content is literally squeezed from it. In the Mansion District the yield varies from 1 gallon to $1\frac{1}{4}$ gallons per 1,000 cubic feet of gas. The oil goes to the bottom of the separator and is drawn out to be run to storage tanks and, ultimately, through a pipe line to a refinery.

With all the protective and control appliances installed, the crucial operation of drilling in takes place. The cement that was used to set the inner string of casing at 6,400 feet extends about 60 feet up from the bottom of the well and must be drilled out. The well is full of mud that weighs from $9\frac{1}{2}$ to 12 pounds per gallon. As the weight of this column would more than offset the bottom-hole pressure when the oil sand is reached, the mud would to some extent penetrate the voids in the sand and clog the formation, thus decreasing production. It is therefore desirable that the column be lightened, and this is done by pumping in water. After the concrete plug is drilled through, the tools are withdrawn from the well while a final check-up of the control equipment is made and the separator and flow lines are connected.

As the drill pipe is lowered into the hole for the final drilling, a stop is made about every 500 to 700 feet to pump out the water. This is done by means of gas-lift. Gas from a compressor plant is introduced through the drill pipe and rises through the column, thereby lightening it and causing the water to flow out of the casing at the top. The compressor plant that serves this purpose is the same as that used in producing completed wells by the gas-lift method. In this case, it consists of four Ingersoll-Rand Type XVG gas-engine-driven units, each of 260 hp. Each compressor has eight vertical power cylinders and four horizontal compressing cylinders of which two are high-pressure and two low-pressure cylinders. The gas enters the low-pressure cylinders at 12 to 15 pounds pressure, is discharged through intercoolers at 90 to 100 pounds, and then passes to the high-pressure cylinders, where it is raised to any desired pressure between 300 and 800 pounds.

For the first 1,000 to 1,500 feet, the pressure required to lift the water and mud from the well is not more than 450 pounds, but at the bottom 600 pounds is needed. After the hole has been thus cleaned, the pumping of gas is continued as drilling into the oil sand is started. Some oil is added to the gas to keep the tools and formation from becoming too dry and to "lubricate" them.

The thickness of the Wilcox sand ranges up to 200 feet in some places, but in this particular area it is customary to drill into it for only about 80 feet. As the formation is penetrated, oil and natural gas begin to come up and to flow into the separator, and because of the presence of this gas the pressure of the gas being pumped in can be lessened. As the oil rises it brings up with it sand from the producing formation. By examining samples of this sand, the geologist knows when the desired horizon in the formation has been reached. As a check on his observations the production is gauged, and drilling stops at the depth that experience has taught will give a well of the most satisfactory performance.

The tools are then withdrawn and 3-inch tubing is extended to the bottom. Through this is pumped gas to assist in raising the oil to the surface. The amount of gas that is introduced will vary with the height to which the oil column rises unassisted in the well and with the volume of the natural gas that is being discharged. The pressure ranges from 300 to 450 pounds. Because of the restrictions imposed, each well is produced only a certain part of each month, and one compressor plant suffices for operating a number of wells. In the Mansion area, the allowable production is very low as compared with the potential production. In November it was $4\frac{1}{2}$ per cent. On this basis, the owner of a well which could yield 12,000 barrels a day was actually allowed to take from it only 16,200 barrels during the month. In October the allowable production was $4\frac{1}{4}$ per cent. It has been as low as 3 per cent.

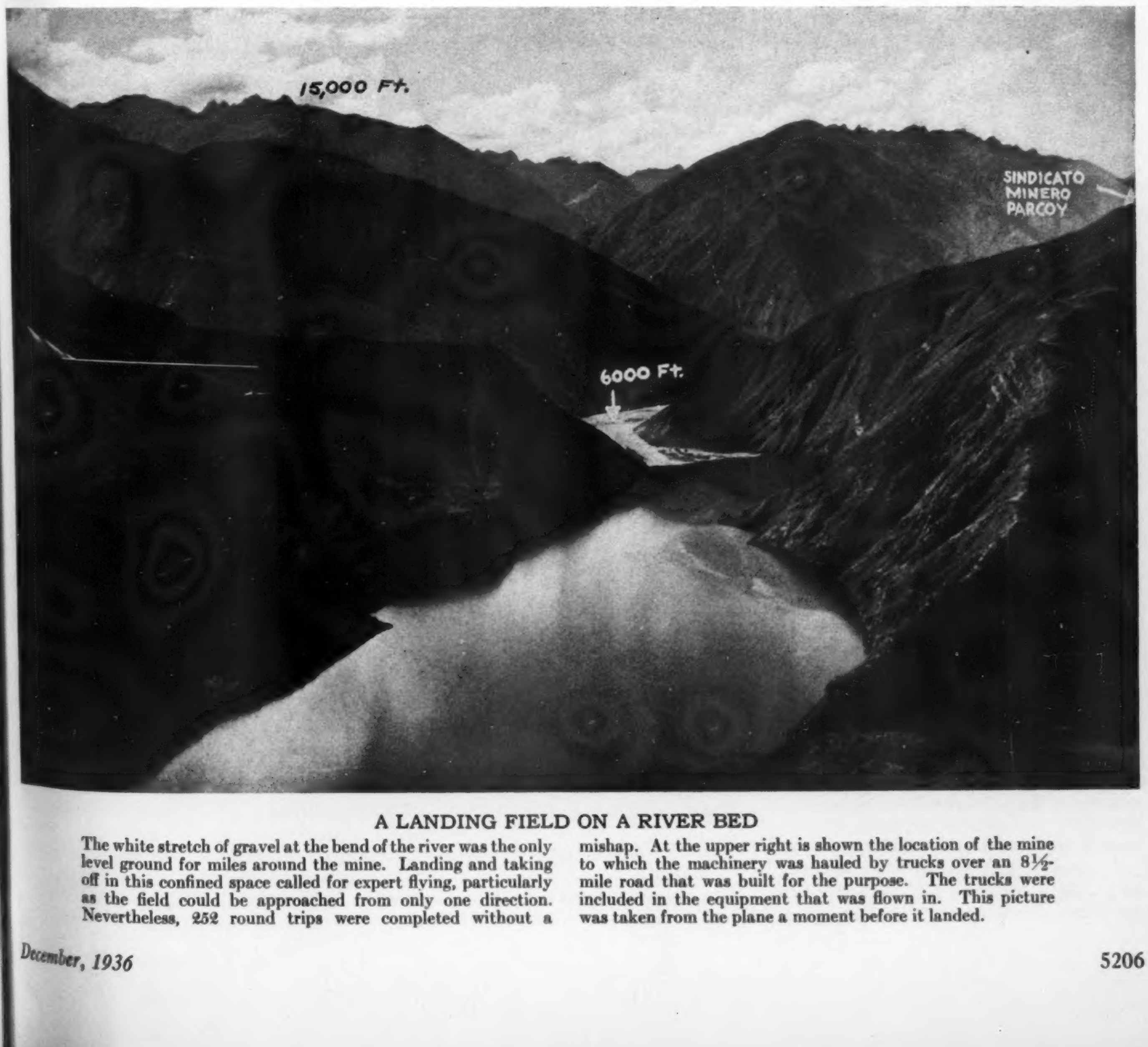
The drilling of a well such as we have described costs from $125,000 to $250,000 and takes from 60 to 90 days. In the end, the owners feel well recompensed for all their trouble if the well comes in with an initial production of from 400 to 600 barrels of oil per hour.

Flying Machinery Into an Andes Mining Camp

UNLOADING CARGO

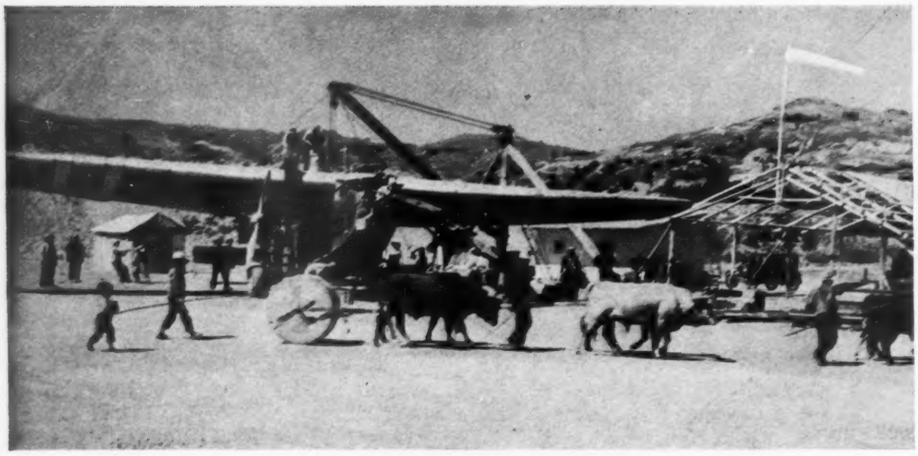
INLAND from Trujillo, Peru, eastward across the Maranon River, are several little dots on the map, one of which indicates Parcoy, a remote spot in the heart of the Andes. Gold ores abound in this vicinity and have been worked for centuries, so much so that profitable production is no longer possible with antiquated methods. Of necessity, therefore, mines must utilize modern machinery, both for mining the ores and for treating them so that the contained metal can be shipped in the form of concentrates. Heretofore a mine that contemplated the installation of such equipment was faced with the major obstacle of transporting the heavy loads to the inaccessible region. At their disposal were only burros to carry pack loads, and ox-drawn sleds to move the heavier pieces. These had to travel a distance of 50 miles over a circuitous route from the nearest point of established lines of communication. The way led through wild mountain country, requiring the fording of two rivers and the crossing of two major elevations, the most severe stretch being an 8,000-foot descent on a trail so steep and tortuous and narrow that even a sure-footed burro occasionally went over a cliff to destruction on the rocks 1,000 feet or more below.

Fortunately, the airplane now provides a quick and dependable means of transporting such equipment. Evidence of this is found in the fact that Aerovias Peruanas, an affiliate company of Pan American-Grace Airways, Inc., not long ago successfully completed a contract for moving 387 tons of machinery consigned to the Sindicato Minero Parcoy. This was ac-



A LANDING FIELD ON A RIVER BED

The white stretch of gravel at the bend of the river was the only level ground for miles around the mine. Landing and taking off in this confined space called for expert flying, particularly as the field could be approached from only one direction. Nevertheless, 252 round trips were completed without a mishap. At the upper right is shown the location of the mine to which the machinery was hauled by trucks over an 8½-mile road that was built for the purpose. The trucks were included in the equipment that was flown in. This picture was taken from the plane a moment before it landed.



HUAMACHUCO LOADING STATION

Here an old lake bed was utilized as an airport. The oxen in the foreground are drawing a concrete roller for smoothing the runway. The plane is being loaded in the background. Exit from the field could be made in only one direction, and the take-off, because of prevailing winds, usually had to be made with a tail wind.

complished in 252 round-trip flights, the average load carried amounting to a little more than 1½ tons.

Because of the ruggedness of the region, the greatest problem in connection with the operations was to find a suitable landing site near the mine. This was solved by using a stretch of gravelly beach in the bend of a river flowing through a deep valley. This beach is dry during the low-flow stage of the stream, but is flooded during the rainy season. On it a straight narrow strip, 65 feet wide and 3,300 feet long, was smoothed off, together with an additional 985-foot emergency section that curved with the river. From there an 8½-mile road was constructed up one side of the gorge and thence to the mine. The freight was transported from the landing field to the mine in trucks that were flown in for the purpose.

Part of an old lake bed near Huamachuco served as a loading and take-off field. At this airport a 65x2,950-foot gravel runway was prepared, and the cargo delivered by trucks that hauled it from the Port of Salaverry 125 miles distant. At both fields cranes were set up for loading and unloading. These were manned by coca-chewing natives of the sections.

The same trimotored Ford plane that the company had previously used on similar freight-carrying contracts was fitted out for the work in hand. The cabin was stripped of all seats and appointments for passenger service, and in it was built a platform that was mounted on rails and could be moved fore or aft by a hand-operated winch. A hatch measuring 50x110 inches was cut in the roof of the cabin, and all heavy pieces were loaded through this opening by the cranes. Pratt & Whitney engines with Hamilton controllable-pitch propellers to facilitate climbing were installed in the outboard nacelles.

Loads were arranged to weigh as nearly as possible 1,400 kilos (3,080 pounds). This permitted taking off at the 10,000-foot altitude, which usually had to be performed with a tail wind, as exit was permissible in but one direction. This load also assured the pilot an easy climb to the required altitude of 14,000 feet and enabled him to maintain an altitude of 13,000 feet on any two motors.

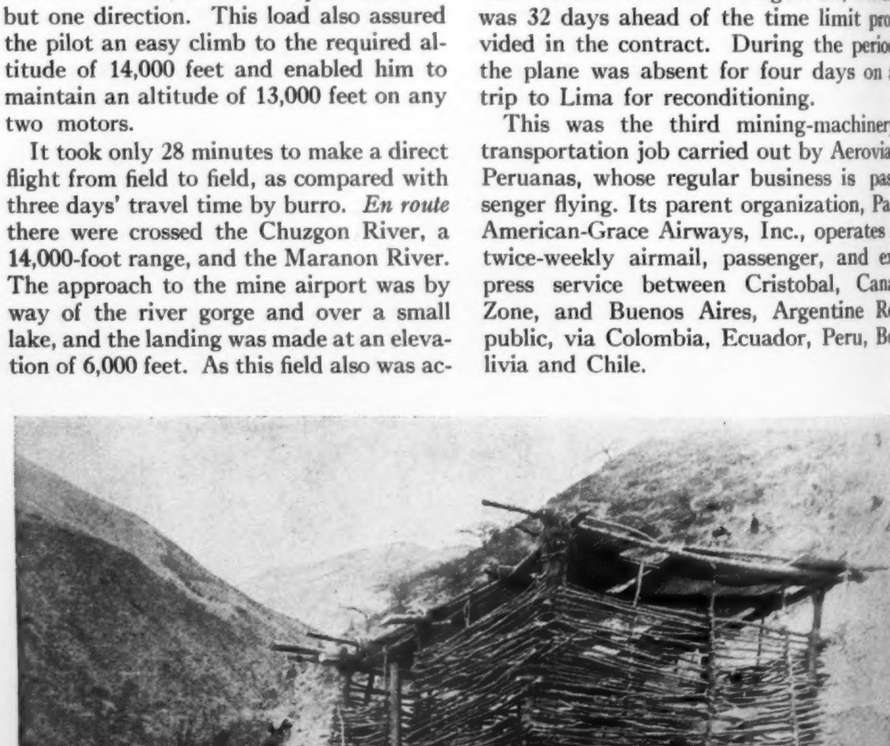
It took only 28 minutes to make a direct flight from field to field, as compared with three days' travel time by burro. *En route* there were crossed the Chuzgon River, a 14,000-foot range, and the Maranon River. The approach to the mine airport was by way of the river gorge and over a small lake, and the landing was made at an elevation of 6,000 feet. As this field also was accessible from only one direction, most of the landings were made with tail winds.

Since weather and winds in the mountains change with startling rapidity, portable radio stations were installed at the fields so that information could be transmitted to the plane whenever conditions necessitated it. This insured maximum safety, eliminated futile trips, and made it possible to utilize all favorable flying periods. As conditions, ordinarily, were better in the early mornings, the first take-off was made at daybreak, about 5:30 o'clock, and flying continued as long as weather and wind permitted. The first trip each day usually aroused the entire town.

The personnel of Aerovias Peruanas consisted of a pilot, a radio co-pilot, a chief mechanic and two assistants, and two ground-station radio operators. Pilots were relieved at frequent intervals, four sharing in the work. Others engaged in the operations were natives supplied by the mining company.

Flights were started on June 28, and the final load was moved on August 26, which was 32 days ahead of the time limit provided in the contract. During the period the plane was absent for four days on a trip to Lima for reconditioning.

This was the third mining-machinery transportation job carried out by Aerovias Peruanas, whose regular business is passenger flying. Its parent organization, Pan American-Grace Airways, Inc., operates a twice-weekly airmail, passenger, and express service between Cristobal, Canal Zone, and Buenos Aires, Argentine Republic, via Colombia, Ecuador, Peru, Bolivia and Chile.



"ADMINISTRATION" BUILDING AT LANDING FIELD

This temporary structure was built from empty steel drums, a few dry branches, and odd pieces of corrugated iron. The truck at the left and the tractor at the right were both flown in from Huamachuco.

EVILS OF THE BID SYSTEM

CUT-THROAT bidding on construction jobs reached its zenith during the depression era. In many cases work was let at ridiculous prices. As a result, contractors had to skimp or lose money, and both they and the public suffered. Many jobs had to be taken over and finished by the principals. Oftentimes the firm best qualified did not get the contract.

How to cure the evils that attend the low-bid system is a problem that warrants serious thought. It has been proposed in England that the next-to-the-lowest bidder, and not the lowest, be given the award. It is argued that this would discourage extreme price-cutting and bring about better performance of contract. Another suggestion is to award the job to a dependable firm whose bid is near the average of all those submitted.

The old adage that you get what you pay for still holds true. Certainly the quality of the job done should be of first consideration. Some fairer scheme than the existing one should be devised for the good of all concerned.

PURER COAL SMOKE

IN ITS fight against the pollution of the atmosphere by coal smoke the Department of Scientific and Industrial Research in Great Britain has arranged an exhibition that has aroused great interest in its mission by showing the effects of various products of coal combustion upon different building materials. There are displays of stone from well-known London buildings, many of which have acquired a film of soot and discoloration that extends more than an eighth of an inch into the surface. Various metals that have been stained and partly destroyed in consequence are also shown.

It has been determined that the burning of a ton of British coal produces, in the damp London climate, 67 pounds of sulphur dioxide. With the addition of water and oxygen from the air, this becomes corrosive sulphuric acid. Besides, considerable quantities of ammonium sulphate, tar, and soot, are emitted from stacks. The solid matter, alone, varies from 10 to 50 pounds for every ton of coal burned in an industrial establishment.

On the other hand, at the Battersea Power Station, the sulphur dioxide issuing from the stacks has been reduced to 4.4 pounds per ton of coal burned. Mechanical stoking, extraction of sulphur, and, most important, an increase in the volume of combustion air from the theoretically required 300,000 cubic feet per ton to 395,000 cubic feet have made this possible.

AID FOR INVENTORS

THE LOT of the inventor has been made easier through the establishment of an organization known as the American Bureau of Invention. It will serve as a clearing house for ideas, lend needed technical advice to inventors, pass impartially upon the soundness and the commercial potentialities of their brain children, and assist them in finding someone interested in developing and making use of them. Meanwhile, the interests of all parties concerned will be legally safeguarded.

In this complicated world, few men possess the specialized knowledge in the diversified fields that often enter into the development of an invention. As a result, many a good idea requires a number of years for its incubation. The bureau proposes to provide all possible shortcuts through the intricacies that are involved. Lack of finances also is frequently an insurmountable barrier to the man with a promising idea. Under the bureau plan, investors or manufacturers will advance money to develop inventions, charging these funds against future royalties or against an agreed purchase price.

The story of the poor inventor who failed to interest anyone in his product, only to have others make a fortune from it later on, is a familiar one in American industry. The newly founded bureau will perhaps make that sort of thing a rare occurrence. In addition, it will render a valuable service to industry by making ideas immediately available to established concerns that can make use of them.

RAILROAD RENAISSANCE

ONE OF the most hopeful signs in the recovery movement is the progress being made by the nation's railroads. Despite the vast increases in the numbers of automobiles, buses, and trucks, the rail carriers are forging ahead slowly but steadily. This is encouraging, because the railroads are admittedly indispensable to the social and economic welfare of the country.

Some of the upturn is attributable to the general betterment of business, but the initiative of the railroads themselves has accounted for no small part of it. Faced with the most stubborn competition in their history, and handicapped by diminished revenues, the railroads nevertheless adopted a progressive policy.

During the depression years air conditioning of railroad cars went steadily forward. At the same time passenger-train speeds were tremendously increased. Only a few years ago 72 hours was required to cross the continent by rail: now it can be done in 40 hours, and with greater comfort besides. The diesel passenger engine and articulated light-weight trains have come upon the scene within the past five years and are already accepted as standard equipment. The 2-cent-per-mile fare is regaining lost passengers, and even roads that fought the fare reduction now acknowledge that it may prove to be their salvation.

The railroads have a long way to come back yet. When they reach normalcy, our economic troubles will in large part have been solved. The basis for this statement is the prediction by competent authorities that the restoration to the railroads of their full purchasing power will give jobs to 5,000,000 men in plants that supply railroad equipment.

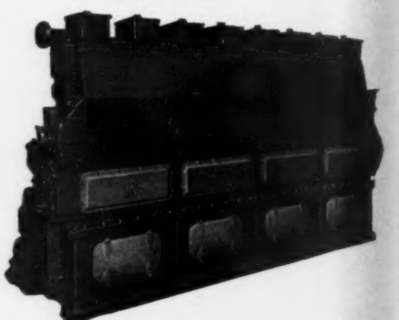
Industrial Notes

Laboratory experiments conducted at Barre, Vt., have shown, reports the U. S. Bureau of Mines, that pulverized waste granite can be used successfully in combination with china clay for the manufacture of porcelain. It has been suggested that the undesirable mica and iron be removed by a process of flotation.

A nail that both holds and seals the hole against moisture is available for general industrial use in connection with galvanized iron building and roofing materials. It is provided with a lead head molded around the steel head, and is prevented from splitting by a small boss that takes the direct blows of the hammer. It is the product of the Filshie Lead Head Nail Company.

Germany, in an effort to make herself self-sustaining, has produced an activated-carbon paint, a protective coating for metals that contains no lead pigments. According to a recent consular report, tests of the new paint have proved it to be "equal and even superior to lead pigments and suitable not only for primary but also for finishing coats." Its range of application is therefore wider than that of the customary rustproof paints.

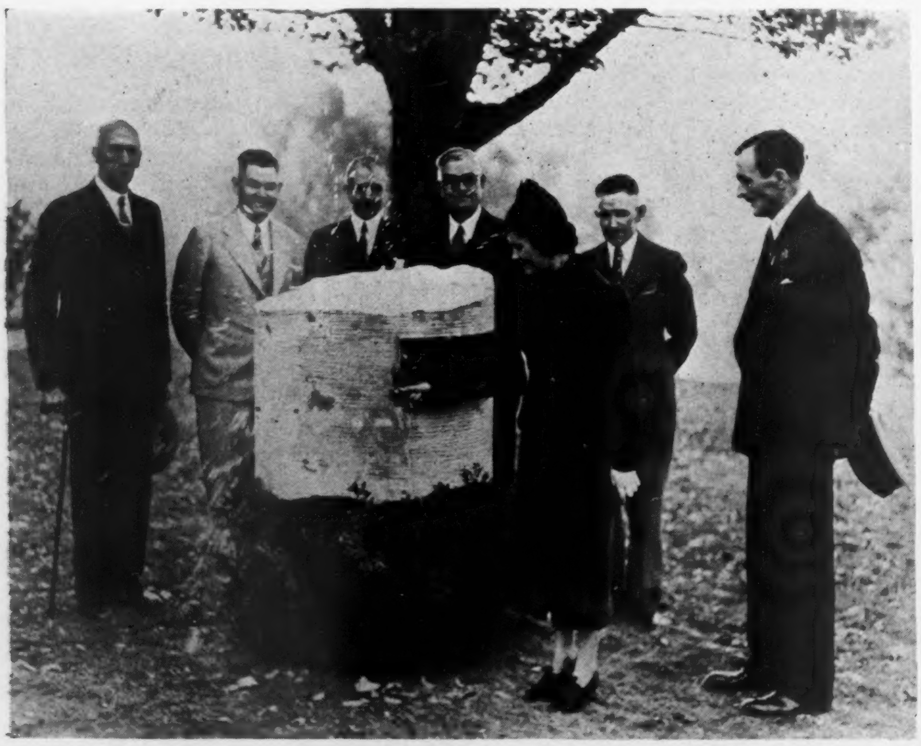
After two years of application in one of the largest automobile plants, a cutting metal is to be generally introduced to the trade under the name of Crobalt. The national distributors—Michigan Tool Company—will furnish the new product either in the form of cutting tools or in bulk, the latter for the use, under licenses, of other toolmakers and machinery manufacturers. The cost of the alloy is said to be low enough to permit whole tools to be made of it, especially the small-sized ones, thus doing away with the prevailing practice of brazing or cementing tips on to tool-steel shanks.



A diesel engine of an improved type has lately been announced by Ingersoll-Rand Company, 11 Broadway, New York, N. Y. It is a vertical, 4-cycle, single-acting, solid-injection engine that is built to run at medium speeds and for heavy-duty, continuous service. Fundamentally, the Type S, as it is designated, is similar in design to the company's locomotive engine, of which there are more than 140 in operation. It is available with three, four, five, six, or eight cylinders for ratings ranging from 150 to 460 hp. A 24-page bulletin, No. 10,010, fully describes this new line of diesels, and will be sent free upon application.

A radical change in tinplating has been announced by the Crucible Steel Company, which has built and put in operation at its Midland, Pa., works a plant equipped for production on a commercial scale. There hot dipping has been supplanted by an electroplating process, which is the invention of J. S. Nachtman who is in charge of the mill. The output consists of tinned strips up to 20 inches wide and in coils weighing up to 5,000 pounds, and of tin plate boxed in the conventional manner. The material is said to be lustrous, nonporous, free from mottles, and of uniform thickness. The plant has been built with an eye to future expansion.

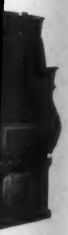
Hipress air hose, a new product of The B. F. Goodrich Company, is designed for use in connection with pneumatic tools of all kinds. It comes in three sizes—½ inch, ¾ inch, and 1 inch—and in lengths of 500 feet. It is made up of two carcasses: an inner one of four plies of specially woven duck and an outer one of tight braid of high-tensile-strength cords. Interposed between the two is a substantial insulation which serves as a secondary tube or seal to prevent the air from reaching the outer walls of the hose and to cushion any blows it might receive. The wrapped construction of the inner carcass provides an ideal backing for the tube proper, which is made of special rubber that is said to be highly resistant to abrasion and abuse and to heat and oil. In short, the construction of the hose is such, according to the manufacturer, that it will give long service and that tiny particles will not break from it and clog up tools.



A SOUVENIR FROM THE BED OF THE COLUMBIA

IF FUTURE generations ever want to know what sort of foundation the Grand Coulee Dam rests on, they can get the information by visiting the campus of the State College of Washington at Pullman, Wash. A 3-foot core of granite that was extracted from the bedrock, 60 feet beneath the base of the dam, has been presented to the school by alumni who are working on the huge project. The core was taken out in the course of the investigation of the dam site by the general contractors, the Mason-Walsh-Atkinson-Kier Company. It was cut by a WS "Calyx" core drill that is owned by the Bureau of Reclamation, the governmental agency that is directing the construction.

The granite cylinder will have a permanent place on the school grounds, and a circular seat will surround it when the installation is complete. The photograph was taken at the dedication ceremonies that were held on October 3. Miss Virginia Thornton, a student at the college and daughter of Prof. C. E. Thornton of the Department of Mechanical Engineering, is shown doing a very complete job of breaking a bottle of Columbia River water upon the stone. The men are, reading from left to right: Prof. H. V. Carpenter, Dean of Engineering at the college; A. F. Darlund, Chief of Field Parties, U. S. Bureau of Reclamation, Grand Coulee Dam; Dr. E. O. Holland, President of the State College of Washington; F. A. Banks, Chief Construction Engineer at Grand Coulee Dam, Bureau of Reclamation; Professor Thornton; and Hon. Clarence D. Martin, Governor of the State of Washington.



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